

IPPS 2024



Israeli Polymers & Plastic Society

The 50th Conference of The Israeli Polymers & Plastic Society

2024

Dr. Maya Kleiman
Conference Chair

Dr. Guy Mechrez
IPPS President



ipps-conference.com



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Welcome Letter

Dear Colleagues,

We are happy to welcome you to the IPPS annual meetings, the 50th Meeting of the Israeli Polymers & Plastics Society (IPPS2024).

We are all experiencing a challenging time but trying to maintain our scientific activity as normal as possible. The decision to postpone the meeting after the inability to hold the original date in December 2023 was very challenging and with mixed feelings. We decided to go ahead with the Conference despite the unusual circumstances and we hope the Conference will be fruitful and enjoyable as much as possible. We extend our deepest gratitude to all the people who worked tirelessly to make this Conference happen.

Our hearts are with the families of the hostages held in Gaza and we hope they will return safely very soon. We send our deepest condolences to the families of the people who were brutally murdered on October 7th and the soldiers and civilians that were killed in the war since. We are dedicating a memorial ceremony during the conference to our dear friends from Kafrit Industries who were murdered on October 7th.

Our meeting will be held on July 2nd in Expo, Tel-Aviv with talks presenting cutting edge research, which reflects the amazing advances made during recent years in many fields of polymers, materials sciences and the plastic industry. We thank our scientific committees for choosing excellent invited speakers, submitted talks and posters. We welcome our two distinguished keynote speakers, who can't join us in person, due to the circumstances, but are happy to share their research, Prof. Emily Cranston, University of British Columbia and Prof. Christoph Weder, University of Fribourg.

We are also excited to honor Prof. Avi Domb from the Hebrew University in Jerusalem with a lifetime achievement award.



The meeting is generously supported by 13 companies, and you are encouraged to visit their booths and learn about the latest technological innovations they present.

We invite you to participate in the Posters session, and chat with the presenters about their work.

We hope that you will enjoy the Conference, find it fruitful and be inspired by the talks and posters and by meetings and discussions with experts and colleagues from all over the world.

On behalf of the IPPS Board and the IPPS2024 organizing committee,

Guy Mechrez,

IPPS President

Maya Kleiman,

IPPS2024 Conference Chair



GENERAL INFORMATION

Venue

Expo Tel Aviv International Convention Center
101 Rokach Boulevard
Tel Aviv 612002
Israel

Climate and Clothing

The average daily temperature in July in Tel Aviv is (Minimum to Maximum):
29-32 C° / 84-91 F°.

Clothing is business casual for all occasions.

Electricity

The Israeli power supply is single phase 220 volts at 50 Hertz. Most power sockets in Israel have three-pin holes, but many of them will work with double-pin European plugs.

Currency and Money Exchange

The currency unit in Israel is the New Israeli Shekel (NIS), "Shekel" in short. International credit cards are accepted for payment in the majority of hotels, restaurants and shops. Most ATMs accept all major credit cards such as Master Card, Visa, Diners, and American Express.

Liability and Insurance

The Conference Secretariat and Organizers of IPPS 2024 cannot accept liability for personal accidents or loss of or damage to private property of participants and accompanying persons. Participants are advised to take out their own personal travel and health insurance for their trip.

IPPS2024 Conference Secretariat

Please do not hesitate to contact the Secretariat if you require any additional information or assistance.

Please address all correspondence to ludovicav@diesenhaus.com



ORGANIZING COMMEETTES

Maya Kleiman, *Conference Chair*, Volcani Institute
Guy Mechrez, *IPPS President*, Volcani Institute

Session Chairs:

Elizabeth Amir, Shenkar – Engineering. Design. Art.
Gerardo Byk, Bar-Ilan University
Shady Farah, Technion – Israel Institute of Science
Jasmine Rosen-Kligvasser, Plaskolite
Anne Bernheim, Ben Gurion University
Ayelet Lesman, Tel Aviv University
Noa Lachman-Senesh, Tel Aviv University
Moran Frenkel-Pinter, Hebrew University of Jerusalem
Ulyana Shimanovich, Weizmann Institute of Science

Conference Secretariat:

Orit Gilad, Diesenhaus Unitours
Ludovica di Veroli, Diesenhaus Unitours
Jennifer Weisberg, Diesenhaus Unitours

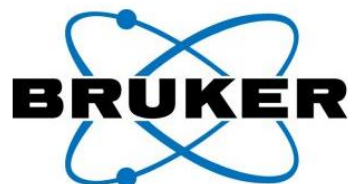


SPONSORS AND EXHIBITORS

Sponsors






Exhibitors









SCIENTIFIC PROGRAM

TUESDAY, JULY 2, 2024		
07:30-09:00	Registration and Breakfast	<i>Foyer</i>
09:00-09:10	Opening Statement	<i>Hall K+L+M</i>
09:10-09:30	Lifetime Achievement and Memorial - Nadav Goldstein	
09:30-09:55	Honorary Membership Award	
09:55-11:15	Keynote Lectures	
09:55-10:35	"Supramolecular Approaches to Detect and Heal Defects in Polymers" <i>Prof. Christoph Weder, University of Fribourg, Switzerland</i>	
10:35-11:15	"Surface Engineering of Cellulose Nanocrystals for Sustainable Bioproduct Development" <i>Prof. Emily Cranston, University of British Columbia, Canada</i>	

11:15-11:45	Coffee Break		Foyer/Exhibition	
11:45-13:30	HALL K+L+M Session 1A: Functional Fabrics and Fibers <i>(In memory of KAFRIT IL fallen)</i>  Chair: Prof. Elizabeth Amir , <i>Shenkar - Engineering. Design. Art</i>	HALL F Session 1B: Materials for biological Applications <i>(In memory of TADBIK fallen)</i>  Chair: Prof. Gerardo Byk , <i>Bar-Ilan University</i>	HALL G Session 1C: Functionalized Polymers <i>(In memory of RAVAL A.C.S. LTD fallen)</i>  Chair: Dr. Shady Farah , <i>Technion - Israel Institute of Technology</i>	HALL H Session 1D: Sustainability Solutions in the Plastic Industry <i>(In memory of MOR PLASTIC INDUSTRIES LTD fallen)</i>  Chair: Dr. Jasmine Rosen-Kligvasser <i>Plaskolite</i>
	11:45-12:05 Invited Lecture: "Long-Range Ordering of Polyelectrolyte Complexes" Eyal Zussman <i>Technion - Israel Institute of Technology</i>	11:45-12:07 Invited Lecture: "Microneedles for Tissue Adhesion, Drug Delivery and as a Platform for Living Materials" Boaz Mizrahi <i>Technion - Israel Institute of Technology</i>	11:45-12:07 Invited Lecture: "Facile One-Step Synthesis of Water-Soluble Cellulose Acetate" Yachin Cohen <i>Technion - Israel Institute of Technology</i>	11:45-12:07 Invited Lecture: "Can We Make a Recycled Material Equivalent to Prime?" Shiran Garnai Hirsch <i>Netafim</i>
	12:05-12:25 Invited Lecture: "Shape-Morphing of Hierarchical Stimuli-Responsive Microfiber-Meshes" Amit Sitt <i>Tel Aviv University</i>	12:07-12:29 Invited Lecture: "Dual Composite Hydrogels as Bioadhesives, Medical Sealants, and Scaffolds for Tissue Regeneration Applications" Meital Zilberman <i>Tel Aviv University</i>	12:07-12:29 Invited Lecture: "Polymeric Architecture as Tool for Programming Transformable Materials" Roey Amir <i>Tel Aviv University</i>	12:07-12:29 Invited Lecture: "The Road to TÜV Biodegradability Certification" Moira Nir <i>Solutum</i>

	HALL K+L+M	HALL F	HALL G	HALL H
	Session 1A: Functional Fabrics and Fibers (cont.)	Session 1B: Materials for biological Applications (cont.)	Session 1C: Functionalized Polymers (cont.)	Session 1D: Sustainability Solutions in the Plastic Industry (cont.)
	12:25-12:45 Invited Lecture: "When Nature meets Nanotechnology: Development of Novel Bio- Composites and Polymers from Renewable Resources" Shachar Richter <i>Tel Aviv University</i>	12:29-12:51 Invited Lecture: "Multifunctional Remotely Targeted Nanoparticles and Mechanical Targeting of Cancer Cells" Ofra Benny <i>The Hebrew University of Jerusalem</i>	12:29-12:51 Invited Lecture: "Salt Dependent Behavior and Properties of Methylcellulose Solutions" Lucy Liberman <i>Technion - Israel Institute of Technology</i>	12:29-12:51 Invited Lecture: "Converting Agricultural Plastic Waste into Value- Added Composite Materials" Jenny Goldman <i>Carmel Olefins</i>
	12:45-13:05 Invited Lecture: "Functional Non- Woven Fabrics Comprising Probiotics" Nir Debotton <i>Shenkar - Engineering. Design. Art.</i>	12:51-13:04 "Novel Non-viral Biocompatible Nano Hydrogel for Gene Delivery" Eswaran Lakshmanan <i>Bar Ilan University</i>	12:51-13:04 Invited Lecture: "Development and Characterization of Integrated Nano-Sensors for Organic Residues and pH Field Detection" Ran Suckeveriene <i>Kinneret Academic Collage</i>	12:51-13:04 "Recycled Rubber Powder from End of Life Tires as a Functional Filler and Additive in Polyolefines - A Circular Economy Approach" Eynat Matzner <i>Tyrec</i>
	13:05-13:18 "One-Dimensional Assembly of Proteins via Electrospinning" Rita Vilensky <i>Technion - Israel Institute of Technology</i>	13:04-13:17 "Thermoplastic Segmented Polyurethane/p oly(L-lactide) Blend as Drug- Eluting Delivery System" Deborah Shalev <i>Azrieli College</i>	Invited Lecture: 13:04-13:17 TBA Qi Wu <i>Technion - Israel Institute of Technology</i>	13:04-13:17 "Environmental Impact Differences in Batch and Flow Chemistry: Case Study of Single-Chain Nanoparticle Production" Or Galant <i>Technion - Israel Institute of Technology</i>

	13:18-13:30 "Electrospinning of Epoxy Fibers: Solution, Process and Mechanical Properties" Mark Shneider <i>Weizmann Institute of Science</i>	13:17-13:30 "Unlocking Next-Gen Polyolefin Degradation by Heat-Resistant Double Emulsions" Jesila Antolin <i>Volcani Institute</i>	Invited Lecture: 13:17-13:30 TBA Eid Marjeh <i>Technion - Israel Institute of Technology</i>	13:17-13:30 "Hydrothermal Decomposition of Plastic — Valorization of Non-Recyclable Mixed Plastic Waste" Ran Darzi <i>Volcani Institute</i>
11:45-13:30	Lunch			
14:45-15:45	Poster Session			
15:45-17:30	HALL K+L+M	HALL F	HALL G	HALL H
	Session 2A: Physics and biophysics of biopolymers <i>(In memory of UBQ fallen)</i>  Chair: Anne Bernheim , <i>Ben-Gurion University</i>	Session 2B: Composite materials <i>(In memory of POLYSACK FLEXIBLE PACKAGING LTD fallen)</i>  Chair: Noa Lachman-Senesh , <i>Tel-Aviv University</i>	Session 2C: Bioinspired and biodegradable polymers <i>(In memory of EREZ THERMOPLASTIC PRODUCTS fallen)</i>  Chair: Moran Frenkel-Pinter , <i>The Hebrew University of Jerusalem</i>	Session 2D: Self-assembly in biomaterials <i>(In memory of RODED RECYCLING INDUSTRIES LTD fallen)</i>  Chair: Ulyana Shimanovich , <i>Weizmann Institute of Science</i>
	15:45-16:07 Invited Lecture: "Mechanical Aspects Govern the Function of Milk Producing Cells in Culture" Yifat Brill-Karniely <i>Volcani Institute</i>	15:45-16:05 Invited Lecture: "What Can We Learn from Nature's Soft Composite Materials?" Mirit Sharabi <i>Ariel University</i>	15:45-16:07 Invited Lecture: "New Biodegradable Materials Based On Nature-Sourced Polysaccharides" Elena Poverenov <i>Volcani Institute</i>	15:45-16:07 Invited Lecture: "Self-Assembly of Short Peptides and Amino Acids into Functional Coatings" Meital Reches <i>The Hebrew University of Jerusalem</i>

	HALL K+L+M	HALL F	HALL G	HALL H
	16:07-16:29 Invited Lecture: "Polymer Physics of DNA and Bacterial Chromatin" Oleg Krichevsky <i>Ben Gurion University</i>	16:05-16:37 Invited Lecture: "Thermal conductivity enhancement of polymer based composite materials" Avia Ohayon <i>Ben Gurion University</i>	16:07-16:29 Invited Lecture: "Bioinspired Materials for Biomedical Applications" Lihi Adler-Abramovich <i>Tel Aviv University</i>	16:07-16:29 Invited Lecture: TBA Ben Palmer <i>Ben Gurion University</i>
	16:29-16:51 Invited Lecture: "The unique properties of fibrous gels and how they mediate cellular interaction" Ayelet Lesman <i>Tel Aviv University</i>	16:37-16:50 "Modifying the Properties and Performance of Biodegradable Polymers with Atomic Layer Deposition" Gil Menasherov <i>Technion - Israel Institute of Technology</i>	16:29-16:51 Invited Lecture: TBA Gonen Ashkenasy <i>Ben Gurion University</i>	16:29-16:51 Invited Lecture: TBA Ido Braslavsky <i>The Hebrew University of Jerusalem</i>
	16:51-17:04 "Engineering Culture Systems with Controlled Properties for Exploring Milk Proteins Secretion" Nir Zaharoni <i>Volcani Institute</i>	16:50-17:03 "Alloy Nanowire Arrays with Controlled Compositions Templated by Block Copolymers" Ofer Burg <i>The Hebrew University of Jerusalem</i>	16:51-17:04 "Bioplastic Material Based on Ethyl Cellulose" Eden Shlush <i>Technion - Israel Institute of Technology</i>	16:51-17:04 "Nitrogen-Rich, Polyethyleneimine-Based, Interpenetrating Network Porous Monoliths: Synthesis and Application" Dahiana Mayer-Keren <i>Technion - Israel Institute of Technology</i>
	17:04-17:17 "Boronic Esters as Dynamic Crosslinks in Covalent Adaptable Network" Tair Sasson <i>Shenkar - Engineering. Design. Art.</i>	17:03-17:16 "Additive Manufacturing of Graphene-Based Composites with Diamonds as High-Volume Fillers" Shani Ligati Schleifer <i>Ben Gurion University</i>	17:04-17:17 "Degradable Porous Polyesters via Emulsion-Templating: Synthesis, Properties, 3D Printing, and Cell Growth" Bar Shlomo-Avitan <i>Technion - Israel Institute of Technology</i>	17:04-17:17 "A Self_Healing Multispectral Transparent Adhesive Peptide Glass" Gal Finkelstein-Zuta <i>Tel Aviv University</i>

	17:17-17:30 "Biocompatibility and Degradation of PLA Reinforced with Tungsten Disulfide Nanotubes for 3D-printed Bone Scaffold" Ofek Golan <i>Tel Aviv University</i>	17:16-17:30 "Technological Synergy: Integration of Polymers and Ceramics in Design, Through Advanced Processes" Ira Shtein Rozenman <i>Shenkar - Engineering. Design. Art. Technology</i>	17:17-17:30 "A Novel Hot-Melt Biodegradable Tissue Adhesive for Bone Fracture Repair" Orel Shem Tov <i>Shenkar - Engineering. Design. Art.</i>	17:17-17:30 "Bioadhesive Microneedle Patches for Tissue Sealing" Eden Freundlich <i>Technion - Israel Institute of Technology</i>
17:30-17:45	Closing Remarks and Best Poster/Talk Award			



IPPS 2024 - ORAL PRESENTATIONS

Session 1A: Functional Fabrics and Fibers

LONG-RANGE ORDERING OF POLYELECTROLYTE COMPLEXES

Eyal Zussman

Department of Mechanical Engineering, Technion - Israel Institute of Technology, Haifa, Israel

SHAPE-MORPHING OF HIERARCHICAL STIMULI-RESPONSIVE MICROFIBER-MESHES

Amit Sitt

School of Chemistry, Tel Aviv University, Tel Aviv, Israel

WHEN NATURE MEETS NANOTECHNOLOGY: DEVELOPMENT OF NOVEL BIO-COMPOSITES AND POLYMERS FROM RENEWABLE RESOURCES

Shachar Richter

Department of Materials Science, Tel Aviv University, Tel Aviv, Israel

FUNCTIONAL NON-WOVEN FABRICS COMPRISING PROBIOTICS

Nir Debotton

Department of Chemical Engineering, Pharmaceutical and Cosmetics Research Center, Shenkar - Engineering. Design. Art, Ramat Gan, Israel

ONE-DIMENSIONAL ASSEMBLY OF PROTEINS VIA ELECTROSPINNING

Rita Vilensky, Ron Avrahami, Patrick Martin, Gleb Vasilyev, Eyal Zussman

Mechanical Engineering Faculty, Technion - Israel Institute of Technology, Haifa, Israel

ELECTROSPINNING OF EPOXY FIBERS: SOLUTION, PROCESS AND MECHANICAL PROPERTIES

Mark Shneider, Israel Greenfeld, Daniel Hanoach Wagner

Department of Molecular Chemistry and Materials Science, Weizmann Institute of Science, Rehovot, Israel



Session 2A:

Physics and biophysics of biopolymers

MECHANICAL ASPECTS GOVERN THE FUNCTION OF MILK PRODUCING CELLS IN CULTURE

Yifat Brill-Karniely

Department of Animal Science, Volcani Institute, Rehovot, Israel

POLYMER PHYSICS OF DNA AND BACTERIAL CHROMATIN

Oleg Krichevsky, Ido Michaelovich

Ben-Gurion University of the Negev, Beer Sheba, Israel

THE UNIQUE PROPERTIES OF FIBROUS GELS AND HOW THEY MEDIATE CELLULAR INTERACTION

Ayelet Lesman

School of Mechanical Engineering, Faculty of Engineering, Tel Aviv University, Tel Aviv, Israel

ENGINEERING CULTURE SYSTEMS WITH CONTROLLED PROPERTIES FOR EXPLORING MILK PROTEINS SECRETION

Nir Zaharoni

Department of Ruminant Science, Volcani Institute, Rehovot, Israel

BORONIC ESTERS AS DYNAMIC CROSSLINKS IN COVALENT ADAPTABLE NETWORK

Tair Sasson¹, Natanel Jarach^{1,2}, Hanna Dodiuk¹

¹Polymer materials engineering, Shenkar – Engineering. Design. Art, Ramat Gan, Israel

²Chemistry and Center for Nanoscience and Nanotechnology, The Hebrew University, Jerusalem, Israel

BIOCOMPATIBILITY AND DEGRADATION OF PLA REINFORCED WITH TUNGSTEN DISULFIDE NANOTUBES FOR 3D-PRINTED BONE SCAFFOLD

Ofek Golan¹, Noa Granada¹, Lin Lemesh¹, Francesca Netti²,

Lih Adler-Abramovich², Noa Lachman¹

¹Department of Materials Science and Engineering, Tel Aviv University, Tel Aviv, Israel

²Department of Oral Biology, Tel Aviv University, Tel Aviv, Israel



Session 1B:
Materials for biological Applications

MICRONEEDLES FOR TISSUE ADHESION, DRUG DELIVERY AND AS A PLATFORM FOR LIVING MATERIALS

Boaz Mizrahi, Neta Shimony, Eden Freundlich, Noa Ben David, Caroline Hali, Adi Gross

Technion - Israel Institute of Technology, Haifa, Israel

DUAL COMPOSITE HYDROGELS AS BIOADHESIVES, MEDICAL SEALANTS, AND SCAFFOLDS FOR TISSUE REGENERATION APPLICATIONS

Meital Zilberman

Department of Biomedical Engineering, Tel Aviv University, Tel Aviv, Israel

NOVEL NON-VIRAL BIOCOMPATIBLE NANO HYDROGEL FOR GENE DELIVERY

Eswaran Lakshmanan, Gila Kazimirsky, Ronen Yehuda, Gerardo Byk

Department of Chemistry, Bar-Ilan University, Ramat Gan, Israel

THERMOPLASTIC SEGMENTED POLYURETHANE/POLY(L-LACTIDE) BLEND AS DRUG-ELUTING DELIVERY SYSTEM

Deborah Shalev, Adel Penhasi, Israel Baluashvili, Sondos Zgayar, Shiyam Edres

Wolfson Centre for Applied Structural Biology, The Hebrew University of Jerusalem, Jerusalem, Israel



Session 2B: **Composite materials**

WHAT CAN WE LEARN FROM NATURE'S SOFT COMPOSITE MATERIALS?

Mirit Sharabi

Department of Mechanical Engineering & Mechatronics, Ariel University, Ariel, Israel

NOVEL EPOXY COMPOSITIONS FOR COMPOSITE MATERIALS - MATERIALS AND PROCESSES

Naum Naveh

Department of Polymer Materials Engineering, Shenkar - Engineering. Design. Art, Ramat Gan, Israel

MODIFYING THE PROPERTIES AND PERFORMANCE OF BIODEGRADABLE POLYMERS WITH ATOMIC LAYER DEPOSITION

Gil Menasherov

Department of Chemical Engineering, Technion - Israel Institute of Technology, Haifa, Israel

ALLOY NANOWIRE ARRAYS WITH CONTROLLED COMPOSITIONS TEMPLATED BY BLOCK COPOLYMERS

Ofer Burg Roy Shenhar

Institute of Chemistry and the Center for Nanoscience and Nanotechnology, The Hebrew University of Jerusalem, Jerusalem, Israel

ADDITIVE MANUFACTURING OF GRAPHENE-BASED COMPOSITES WITH DIAMONDS AS HIGH-VOLUME FILLERS

Shani Ligati Schleifer¹, Oren Regev^{1,2}

¹*Department of Chemical Engineering, Ben-Gurion University of the Negev, Beer Sheva, Israel*

²*The Ilse Katz Institute for Nanoscale Science and Technology, Ben-Gurion University of the Negev, Beer Sheva, Israel*

TECHNOLOGICAL SYNERGY: INTEGRATION OF POLYMERS AND CERAMICS IN DESIGN, THROUGH ADVANCED PROCESSES

Ira Shtein Rozenman

Master in Design, Shenkar - Engineering. Design. Art, Ramat Gan, Israel



Session 1C: Functionalized Polymers

FACILE ONE-STEP SYNTHESIS OF WATER-SOLUBLE CELLULOSE ACETATE

Yachin Cohen¹, Dmitry M. Rein¹, Gilad Alfassi²

¹Chemical Engineering, Technion - Israel Institute of Technology, Haifa, Israel

²Biotechnology Engineering, Braude College of Engineering, Karmiel, Israel

POLYMERIC ARCHITECTURE AS TOOL FOR PROGRAMMING TRANSFORMABLE MATERIALS

Roey Amir

School of Chemistry, Tel Aviv University, Tel Aviv, Israel

The ADAMA Center for Novel Delivery Systems in Crop Protection,

Tel Aviv University, Tel Aviv, Israel

DEVELOPMENT AND CHARACTERIZATION OF INTEGRATED NANO-SENSORS FOR ORGANIC RESIDUES AND PH FIELD DETECTION

Ran Suckeveriene

*Water Industry Engineering Department, Kinneret Academic College, Zemach,
Israel*

TBA ENGINEERING LINEAR AND CROSSLINKED NANOPARTICLES DUAL FUNCTIONALIZED URACIL AND HYDANTOIN-BASED ANTIVIRAL/ANTIMICROBIAL POLYMERS

Eid Nassar-Marjiya

*Farah Laboratory for Advanced Functional/Medicinal Polymers & Smart Drug
Delivery Technologies, Technion - Israel Institute of Technology, Haifa, Israel*



Session 2C: Bioinspired and biodegradable polymers

NEW BIODEGRADABLE MATERIALS BASED ON NATURE-SOURCED POLYSACCHARIDES

Elena Poverenov

Volcani Institute, Rishon Le Zion, Israel

BIOINSPIRED MATERIALS FOR BIOMEDICAL APPLICATIONS

Lihl Adler-Abramovich

*Department of Oral Biology, The Goldschleger School of Dental Medicine,
Faculty of Medicine & Health Sciences, The Center for Nanoscience and
Nanotechnology, Tel Aviv University, Tel Aviv, Israel*

BIOPLASTIC MATERIAL BASED ON ETHYL CELLULOSE

Eden Shlush, Maya Davidovich-Pinhas

*Department of Biotechnology and Food Engineering, Technion – Israel Institute of
Technology, Haifa, Israel*

DEGRADABLE POROUS POLYESTERS VIA EMULSION-TEMPLATING: SYNTHESIS, PROPERTIES, 3D PRINTING, AND CELL GROWTH

Bar Shlomo-Avitan, Samah Saied Ahmad, Yoav Friedle, Hila Toledo,
Michael Silverstein

Technion - Israel Institute of Technology, Haifa, Israel

A NOVEL HOT-MELT BIODEGRADABLE TISSUE ADHESIVE FOR BONE FRACTURE REPAIR

Orel Shem Tov, Anna Dotan, Dan Lewitus

*Department of Polymer Materials Engineering, Shenkar College, Ramat-Gan,
Israel*



Session 1D:

Sustainability Solutions in the Plastic Industry

CAN WE MAKE A RECYCLED MATERIAL EQUIVALENT TO PRIME?

Shiran Garnai Hirsch¹, Yoav Shay¹, Oz Gazit²

¹Global Materials R&D and Technologies, Netafim LTD, Magal, Israel

²Department of Chemical Engineering, Technion - Israel Institute of Technology, Haifa, Israel

THE ROAD TO TÜV BIODEGRADABILITY CERTIFICATION

Moira Nir, PhD

R&D Department, Solutum Technologies, Ltd., Tel Aviv, Israel

CONVERTING AGRICULTURAL PLASTIC WASTE INTO VALUE-ADDED COMPOSITE MATERIALS

Jenny Goldman¹, Rotem Shemesh¹, Michael Gishvoliner¹, Anna Dotan², Shy Adar Lev-Or³, Yori Costa³

¹*R&D, Carmel Olefins, Haifa, Israel*

²*Department of Plastics Engineering, Shenkar - Engineering. Design. Art, Ramat Gan, Israel*

³*R&D, Tama, Kibbutz Mishmar HaEmek, Israel*

RECYCLED RUBBER POWDER FROM END OF LIFE TIRES AS A FUNCTIONAL FILLER AND ADDITIVE IN POLYOLEFINES - A CIRCULAR ECONOMY APPROACH

Eynat Matzner, Nataly Vainrot

R+D, Tyrec Ltd, Shahak Industrial Zone, Israel

ENVIRONMENTAL IMPACT DIFFERENCES IN BATCH AND FLOW CHEMISTRY: CASE STUDY OF SINGLE-CHAIN NANOPARTICLE PRODUCTION

Or Galant¹, Charles E. Diesendruck², Sabrina Spatari¹

¹Department of Environmental and Civil Engineering, Technion - Israel Institute of Technology, Haifa, Israel

²Schulich Faculty of Chemistry, Technion - Israel Institute of Technology, Haifa, Israel



HYDROTHERMAL DECOMPOSITION OF PLASTIC — VALORIZATION OF NON-RECYCLABLE MIXED PLASTIC WASTE

Ran Darzi¹, Yael Dubowski¹, Roy Posmanik²

¹Department of Civil and Environmental Engineering, Technion - Israel Institute of Technology, Haifa, Israel

²Department of Water and Environmental Science, Neve Ya'ar Research Center, Agricultural Research Organization, Neve Ya'ar, Israel



Session 2D: Self-assembly in biomaterials

SELF-ASSEMBLY OF SHORT PEPTIDES AND AMINO ACIDS INTO FUNCTIONAL COATINGS

Meital Reches

Institute of Chemistry, The Hebrew University of Jerusalem, Jerusalem, Israel

NITROGEN-RICH, POLYETHYLENEIMINE-BASED, INTERPENETRATING NETWORK POROUS MONOLITHS: SYNTHESIS AND APPLICATION

Dahiana Mayer-Keren¹, Michael S. Silverstein²

¹Interdisciplinary Program in Polymer Engineering, Technion - Israel Institute of Technology, Haifa, Israel

²Department of Materials Science and Engineering, Technion - Israel Institute of Technology, Haifa, Israel

A SELF HEALING MULTISPECTRAL TRANSPARENT ADHESIVE PEPTIDE GLASS

Gal Finkelstein-Zuta

Material science, Tel Aviv University, Tel Aviv, Israel

BIOADHESIVE MICRONEEDLE PATCHES FOR TISSUE SEALING

Eden Freundlich

Faculty of Biotechnology and Food Engineering, Technion – Israel Institute of Technology, Haifa, Israel



IPPS 2024 – FULL ORAL PRESENTATIONS

Session 1A: Functional Fabrics and Fibers

Invited Lecture

LONG-RANGE ORDERING OF POLYELECTROLYTE COMPLEXES

Eyal Zussman¹

*Department of Mechanical Engineering, Technion - Israel Institute of
Technology, Haifa, Israel*

Electrostatic interactions between polyelectrolyte (PE) charges and dissociated counterions provide PEs with intriguing properties and significantly determine their conformation and dynamics. When oppositely charged PEs are mixed, the variety of the compositions spans from poorly processable, kinetically trapped PE complexes (solid) to coacervates (elastic liquid) to dissolved solutions with increasing salt concentration, pH level, or charge asymmetry. Creating fibers or films with controlled microstructure from PE complex typically requires a global network that will impart viscoelastic properties. Nonetheless, regulating the structure and dynamics of a global network comprised of PE complexes remains a research challenge. This research shows how weak PE chains form a global network when they are oppositely charged and how strong electric fields lead to orientational order. The development of controlled drug release and responsive structures is demonstrated by the use of ordered PE with tunable intermolecular interactions.



Invited Lecture

SHAPE-MORPHING OF HIERARCHICAL STIMULI-RESPONSIVE MICROFIBER-MESHES

Amit Sitt¹

School of Chemistry, Tel Aviv University, Tel Aviv, Israel

Hierarchical active networks made of mesoscale filaments are pervasive in biological systems and play a pivotal role in a wide range of processes, including cell division, application of directional forces, and motility. Crafting synthetic equivalent meshes with microscale precision is a formidable task and requires high control of the mesh components. In this talk, I will present the fabrication of soft, highly ordered 2D meshes, hierarchically assembled from thermoresponsive microscale polymeric fibers. The inherent hierarchical architecture of these meshes gives rise to distinctive and intricate shape-morphing behaviors, which depend on the properties of the individual filaments, as well as the density and symmetry of the mesh. I will examine the different morphing behaviors of microfiber networks and describe how a comprehensive understanding of the underlying physics provides a foundation for orchestrating and programming the morphing dynamics within these networks. This knowledge holds the potential to advance the development of soft actuators and artificial muscles with microscale morphing resolutions, thereby paving the way for innovative applications in this domain.



Invited Lecture

**WHEN NATURE MEETS NANOTECHNOLOGY: DEVELOPMENT OF
NOVEL BIO-COMPOSITES AND POLYMERS FROM RENEWABLE
RESOURCES**

Shachar Richter¹

*Department of Materials Science, Tel Aviv University, Tel Aviv,
Israel*

Renewable resources are of great importance since they can be used for the benefit of humankind while helping to resolve ecological and environmental issues. In this respect, Protein-based materials from renewable resources are of particular interest since, from a material science point of view, proteins can serve as excellent building blocks for developing new structures, composites, and novel materials.

In this talk, I will cover some of our efforts in this direction, demonstrating our bottom-up technologies to form various new polymers, including light-emitting devices, photothermal materials, smart-wound dressing, antibacterial coating, heavy-metal sorption materials, and more. The role of Jellyfish, an important renewable resource for many of our applications, will be discussed.



Invited Lecture

FUNCTIONAL NON-WOVEN FABRICS COMPRISING PROBIOTICS

Nir Debotton¹

*Department of Chemical Engineering, Pharmaceutical and
Cosmetics Research Center, Shenkar - Engineering, Design, Art,
Ramat Gan, Israel*

In recent years, the exploration of probiotic bacteria in dermatology has garnered increasing attention for its potential to address various skin conditions, such as aging, acne, wound healing, burns, yeast, and bacterial infections. Innovative strategies have emerged, including the application of functional materials like probiotics onto the skin, particularly through functional fabrics, which are gaining interest in textile research and industry.

This study introduces a novel technology focused on developing functional non-woven fabric embedding hydrogel-based particulate matter containing beneficial bacillus bacteria. Micro-flakes (μ Fs), composed of alginic acid, were utilized, demonstrating a flat, lamellar shape presumed to enhance adherence to the skin surface.

Their irregular shape also facilitated the non-covalent attachment of μ Fs to fibres, ensuring anchoring into the fabric.

The production process emphasized simplicity obtained μ F size averaging $134 \pm 8 \mu\text{m}$. The encapsulation efficiency reached $65.4 \pm 12 \%$, indicating high survival of bacillus coagulans probiotics post-encapsulation. Industrial-scale production was achieved via Gravure Printing, followed by drying.

Viability tests showed 108 bacteria per square cm of dried fabric, with stability confirmed for at least 23 weeks at room temperature and 40°C . In addition, the study investigated the release of the bacterial cargo from μ Fs, revealing electrolytes as triggers for enhanced release. This smart release mechanism responds to environmental changes, particularly electrolyte concentrations on the skin.

Furthermore, evaluation of probiotic fabrics containing 107-108 bacillus bacteria/cm² on irritated human skin specimens demonstrated a significant recovery in skin viability. Additionally, probiotic cosmetic masks showed pronounced effects in human subjects, further emphasizing the promising outcomes of this invention. These

investigations highlight the potential of this technology to enhance skin regeneration and address dermal inflammation disorders.



In conclusion, this study presents a promising approach to utilizing probiotic bacteria in dermatological applications through functional fabrics. The developed technology offers simplicity in production, robust viability, and smart release mechanisms, demonstrating potential benefits for skin health and cosmetic applications. Further research and development in this area could lead to novel interventions for various skin conditions.



ONE-DIMENSIONAL ASSEMBLY OF PROTEINS VIA ELECTROSPINNING

Rita Vilensky¹, Ron Avrahami¹, Patrick Martin¹, Gleb Vasilyev¹,
Eyal Zussman¹

*Mechanical Engineering Faculty, Technion - Israel Institute of
Technology, Haifa, Israel*

Electrospinning is a versatile and widely employed technique for fabricating fibers through subjecting polymer solutions to an electric field. While electrospinning has predominantly been applied to synthetic polymers, there is a growing interest in exploring its potential with proteins, owing to their inherent biocompatibility and bioactivity.^{1–3} However, the inherent compact tertiary structure of globular proteins, which lacks the customary physical entanglements, imparts a notable challenge to their spinnability. Herein we utilized associative interactions, including hydrogen bonds or electrostatic coupling, to endorse the spinnability of globular protein. We used highly available globular protein, bovine serum albumin (BSA) and branched polyethyleneimine (PEI) in a trifluoroethanol/water mixed solvent. A correlation between the rheological behavior and the spinnability of the system was established. All precursor solutions revealed gradual transformation from Newtonian, through pseudo-plastic to viscoplastic rheological response with BSA/PEI ratio-dependent kinetics. Successful electrospinning was realized when the solutions exhibited pseudoplastic behavior. HRSEM of as-spun mats showed uniform fibers of ~1mm in diameter. Increasing the PEI content resulted in enhanced stability of the fibers upon immersion in aqueous media, indicating the BSA-PEI electrostatic cross-linking improves the fibers stability.

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ELECTROSPINNING OF EPOXY FIBERS: SOLUTION, PROCESS AND MECHANICAL PROPERTIES

Mark Shneider¹, Israel Greenfeld¹, Daniel Hanoch Wagner¹
*Department of Molecular Chemistry and Materials Science,
Weizmann Institute of Science, Rehovot, Israel*

Electrospinning of thermoplastic polymers is a common and relatively easy way to produce nanofibers, widely used in applications such as filters and coatings. Still, only recently has it been applied to thermosetting polymers because of their chemical structure and reactivity. Epoxy is a thermosetting polymer which, when combined with a curing agent, chemically reacts to form a crosslinked matrix. Electrospinning of epoxy has scarcely been studied, and therefore little is known about the chemical state of the solution for electrospinning and the resulting mechanical properties of the fibers.

In this study, the electrospinning processing of an epoxy solution is demonstrated. An analysis of the solution at different curing times is performed, and the mechanical properties of the fibers are tested. Rheological measurements and Fourier transform infrared spectroscopy (FTIR) analysis are employed to modulate critical transformations during the curing reaction. Tensile and polarized micro-Raman tests are conducted to assess the mechanical properties and molecular orientation of the fibers.

Comparing epoxy bulk to fibers, our results reveal significant enhancements in the tensile properties of electrospun epoxy fibers, exhibiting approximately 270% higher strength and stiffness, along with a 900% higher elongation and 1200% higher toughness. Additionally, a size-dependence of strength on fiber diameter is observed, with fibers as small as 410 nm exhibiting strengths over 970 MPa, compared to approximately 70 MPa for bulk epoxy. The results suggest that epoxy fibers possess superior mechanical properties, potentially making them pivotal in various scientific and industrial applications requiring chemical and thermal resilience, such as filtration, coatings, and polymer composites.



Session 2A:
Physics and biophysics of biopolymers

Invited Lecture

**MECHANICAL ASPECTS GOVERN THE FUNCTION OF MILK
PRODUCING CELLS IN CULTURE**

Yifat Brill-Karniely¹

Department of Animal Science, Volcani Institute, Rehovot, Israel

The secretion of caseins and whey proteins by mammary gland epithelial cells in culture largely depends on the mechanical environment of the cells. This is in accordance with the tight cross-talk between the physical state of the tissue and the lactation phase in the live animal. Mammary glands undergo substantial mechanical alterations during developmental cycles, manifested in changing rigidity, density and architecture. While it is well known that mechanical aspects regulate mammary gland function, very little is known about the responses of mammary cells to mechanical manipulations and their link with the secretion of milk proteins. The talk will present several culture systems developed in our new lab for investigation of these questions in bovine mammary epithelial cells. Specifically, we examine how physical manipulations, that can mimic physiological conditions in the live animal, affect the cellular function. As demonstrated in the figure below, these include passive manipulations, such as changing the culture topography, or active ones, in which mechanical force is exerted over the sample. Our multidisciplinary work comprises 2D and 3D culture systems, force spectroscopy, milk protein detection and physical modelling. Using these tools we gain comprehensive insight about the link between the micro-environmental conditions, the mechanical cell properties, and the expression of milk proteins.



Invited Lecture

POLYMER PHYSICS OF DNA AND BACTERIAL CHROMATIN

Oleg Krichevsky, Ido Michaelovich

I will describe our adaptation of Scanning Fluorescence Correlation spectroscopy (sFCS) to measure the structure factor of DNA solutions. Scanning the sample at the high speeds essentially converts the temporal correlation function into the spatial correlation function. Fourier analysis of the sFCS functions and of the sampling volume characteristics produces the structure factor of the solutions.

I will present our measurements of the structure of DNA solutions in dilute and semi-dilute regimes that demonstrate a wide range of the “marginal” regime characteristic of semiflexible polymers predicted by Schaefer, Joanny and Pincus (*Macromol.* 13, 1280, 1980). Then I will describe our efforts to elucidate the structure of bacterial chromatin that appears to be consistent with the fractal globule model proposed by Grosberg, Rabin, Havlin and Neer (*EPL* 23, 373, 1993).



Invited Lecture

THE UNIQUE PROPERTIES OF FIBROUS GELS AND HOW THEY MEDIATE CELLULAR INTERACTION

Ayelet Lesman¹

*School of Mechanical Engineering, Faculty of Engineering, Tel Aviv
University, Tel Aviv, Israel*

The extracellular matrix (ECM) of living tissues is a unique soft gel-like material made of fibrous networks like collagen (e.g., in connective tissues) and fibrin (e.g., in wound healing). The mechanical interaction between cells and their local microenvironment allows for cellular interaction and guides various cell behaviour and collective processes.

In this talk, I will share our recent work dedicated to understanding how cells remodel and modify their local fibrous environment to mechanically communicate with each other, over distances much larger than the cell size. This includes our recent measurements using optical tweezers of force propagation and local mechanics of fibrous gels in response to "cell-like" applied force and externally-applied force. Using controlled cellular experiments, having well-defined cellular configuration in gels, we get insights onto emergent collective mechanical interaction in cell population. Inspired by how cells mechanically remodel the environment, and response to it, we engineer systems to guide and direct cell behaviour for tissue engineering applications.



ENGINEERING CULTURE SYSTEMS WITH CONTROLLED PROPERTIES FOR EXPLORING MILK PROTEINS SECRETION

Nir Zaharoni¹

Department of Ruminant Science, Volcani Institute, Rehovot, Israel

The milk producing cells in mammals' mammary glands are the mammary epithelial cells (MECs). These cells express variety of biopolymers, comprising the rich valuable content of natural milk. Abundant secretion of bovine milk components in culture (such as caseins, whey proteins and fat globules), is a main goal in the cultured milk theme, which aims to produce dairy products without milking for ecological and economical benefits. For other mammals it was found that the physical micro-environment governs the functionality of MECs in producing milk components in culture. However, very little is known about the responses of bovine mammary cells to mechanical manipulations and their effect on the secretion of milk components. For addressing these questions experimental systems are required in which the mechanical environment of bovine MECs can be controlled, in a manner that can mimic physiological conditions. The poster will present several culture systems designed in our lab for that aim. We vary both passive culture conditions, such as the architecture and the adherence of the substrate, as well as active conditions manifested in the application of external force. Our preliminary results show that the mechanical state of the culture can be well controlled, and that bovine MECs grow well in the variant conditions, indicating on the potential of these methods in studying the link between MECs biomechanics and functionality.



BORONIC ESTERS AS DYNAMIC CROSSLINKS IN COVALENT ADAPTABLE NETWORK

Tair Sasson¹, Natanel Jarach^{1,2}, Hanna Dodiuk¹

¹*Polymer materials engineering, Shenkar – Engineering. Design. Art, Ramat Gan, Israel*

²*Chemistry and Center for Nanoscience and Nanotechnology, The Hebrew University, Jerusalem, Israel*

In the ever-evolving landscape of materials, polymers stand as both essential and environmentally challenging. Traditionally divided into thermosets and thermoplastics, their lack of reusability has been a drawback. Enter covalent adaptable networks (CANs), seamlessly blending durability with recyclability. Among the stars of this innovation are pH-responsive polymers like boronic esters, offering versatility and sustainability. Recent advancements in crosslinked polymers fortified with B-O bonds, particularly boronic esters, promise both stability and reversibility, enabling effortless reprocessing and recycling. It's a game-changer, ensuring sustainability without compromising on performance.

This research unlocks a revolutionary method for creating reversible crosslinking materials using photo generators and pH changes between guar gum and boric acid. This is a major leap for sustainable design in biomedicine, radiation curing adhesive, and 3D printing - booming industries valued at billions. By bridging a crucial knowledge gap in boronic acid chemistry, this research empowers future advancements in these fields.



BIOCOMPATIBILITY AND DEGRADATION OF PLA REINFORCED WITH TUNGSTEN DISULFIDE NANOTUBES FOR 3D-PRINTED BONE SCAFFOLD

Ofek Golan¹, Noa Granada¹, Lin Lemesh¹, Francesca Netti², Lihi Adler-Abramovich², Noa Lachman¹

¹*Department of Materials Science and Engineering, Tel Aviv University, Tel Aviv, Israel*

²*Department of Oral Biology, Tel Aviv University, Tel Aviv, Israel*

Recent advancements in bone tissue engineering have increased interest in 3D-printed scaffolds for bone regeneration, overcoming the limitations of traditional bone grafts. Among the materials examined worldwide for bone scaffolds, Polylactic-acid (PLA) stands out as a promising candidate. PLA is a biocompatible and biodegradable polyester with significant medical application potential. Reinforcing PLA with inorganic nanotubes of tungsten disulfide (INT-WS₂) enhances its suitability as a bone scaffold due to the chemical stability, biocompatibility, non-toxicity, and favorable mechanical properties of INT-WS₂.

This study investigates the morphological and mechanical properties under hydrolysis degradation, and the biocompatibility of 3D-printed samples made from PLA reinforced with 0.5%wt INT-WS₂ as a concept for a 3D-printed femur bone (hip) scaffold.

Controlled hydrolysis degradation of the PLA/INT-WS₂ samples was conducted over 12 weeks to simulate human-body conditions. Degradation was evaluated by weight loss, differential scanning calorimetry (DSC), and gel permeation chromatography (GPC), while mechanical properties were assessed via tensile strength and micro-hardness tests. Sample morphology was analyzed using scanning electron microscopy (SEM), and biocompatibility was examined by alamarBlue assays on both PLA/INT-WS₂ and neat PLA (used as control) filaments and printed samples. Results demonstrated that the PLA/INT-WS₂ nanocomposite exhibited non-toxic behavior, promoting cell proliferation and viability. Additionally, the material underwent bulk degradation while maintaining mass and surface hardness properties. Although a slight decrease in tensile strength was observed, the ultimate tensile strength remained significantly higher than the maximum stress experienced during normal walking on the human femur bone.

Despite the need for a longer experiment to fully assess the degradation rate, this study indicates that PLA reinforced with 0.5wt% INT-WS₂ is a suitable candidate for a tailored 3D-printed bone scaffold for individual patients.



Session 1B: Materials for biological Applications

Invited Lecture

MICRONEEDLES FOR TISSUE ADHESION, DRUG DELIVERY AND AS A PLATFORM FOR LIVING MATERIALS

Neta Shimony, Eden Freundlich, Noa Ben David, Caroline Hali, Adi
Gross, **Boaz Mizrahi**

A microneedle (MN) patch is a minimally invasive apparatus composed of micron-sized needles arranged on a small patch. Interest in MN technology has been growing steadily in recent decades and is expected to keep increasing following the publication by the US Food and Drug Administration (FDA.) We have proposed an innovative approach to developing a strong, yet elastic MNs composed of bio-adhesive methodologies combined with interlocking and swelling approaches. In addition, we have studied the use of drug loaded MNs for Atopic dermatitis treatment. Finally, we have designed and fabricated novel living delivery systems (live bacteria in polymer concept) for the continuous production of beneficial bio-molecules in-situ (e.g. onto the skin). Many methods and characterization techniques will be reviewed including organic synthesis, mechanical properties and adhesion tests, in vitro and in vivo experiments. The needle structure enables arrays to strongly fix onto various tissues while presenting excellent sealing and adhesive properties. A single MN stopped intense liver bleeding significantly quicker and with less blood loss compared with commercial oxidized cellulose patches. When similar MN contained dexamethasone, a significant clinical improvement, including in the dermatitis score, spleen weights, and clinical scores, were observed in vivo. Taken together, MNs can be considered a promising cost-effective platform for adhesion and sealing of tissues and as a pain free drug delivery system that does not require trained medical staff and equipment.



Invited Lecture

DUAL COMPOSITE HYDROGELS AS BIOADHESIVES, MEDICAL SEALANTS, AND SCAFFOLDS FOR TISSUE REGENERATION APPLICATIONS

Meital Zilberman¹

Department of Biomedical Engineering, Tel Aviv University, Tel Aviv, Israel

There is an increasing interest in new polymeric systems for various clinical applications, that will be based on known materials, obviating the need for development of new polymers.

We have developed dual composite formulations and processing methods for converting natural-based hydrogel networks to biomedical applications. In order to enhance the mechanical- physical properties and functionality, combination of two types of functional materials were added: hemostatic agents and cellulose fibers or hydroxyapatite. Incorporation of hemostatic agents and fibers are beneficial for soft tissue and applications, while incorporation of hemostatic agents and hydroxyapatite are beneficial for hard tissue applications. The effects of the formulation parameters and processing conditions on the physical, mechanical and biological properties were elucidated. In-vivo studie were performed as well.

Our results show that the addition of functional fillers enabled to increase the tensile strength and modulus of the bulk hydrogel, leading to both, higher sealing ability and higher bonding strength. The gelation time and swelling degree significantly decreased and the viscosity increased with the functional fillers incorporation, which all together enables better functioning.

We showed that our novel concept of dual-composite hydrogels, combined with appropriate formulation parameters, new processing methods and nano/micro structuring effects, is of great scientific and medical relevance, and is expected to provide new solutions to basic needs in various medical fields.



Invited Lecture

**MULTIFUNCTIONAL REMOTELY TARGETED NANOPARTICLES AND
MECHANICAL TARGETING OF CANCER CELLS**

Ofra Benny¹

*Institute for Drug Research, School of Pharmacy, Faculty of
Medicine, The Hebrew University, Jerusalem, Israel*

The integration of engineering with biology led to recent breakthroughs in medicine which are expected to improve human wellbeing and lifespan. Nanomedicine introduces new tools to fight complex diseases such as cancer, which is the leading cause of death worldwide. Interactions between nanomaterials and living cells or tissues are critical for the efficacy of drug delivery. This issue is especially critical in cancer since chemotherapy drugs are toxic and can detrimentally affect healthy tissue. By controlled fabrication of nanoparticle drug carriers we can better target and focus therapy based on physical parameters thus improving drug efficacy and reducing adverse side effects. Remotely actuated nanoparticles can be designed to be controlled remotely by magnetic forces by using metal-polymer hybrid nanoparticles. These hybrid nanoparticles were shown to improve drug targeting in cancer and introduce synergistic multi-arm therapy. Finally, by using advanced microfluidic techniques for “tumor on a chip” platforms, we can measure the effects of drugs and nanotherapeutic therapies on patient-derived tissues to provide personalized drug selection tool prior to clinical testing.



NOVEL NON-VIRAL BIOCOMPATIBLE NANO HYDROGEL FOR GENE DELIVERY

**Eswaran Lakshmanan¹, Gila Kazimirsky¹, Ronen Yehuda¹,
Gerardo Byk¹**

Department of Chemistry, Bar-Ilan University, Ramat Gan, Israel

Here in, we have designed, synthesized, and characterized novel cross-linked monodispersed nanohydrogels (NHGs) with well-defined sizes ranging between 50–400 nm for nucleic acid packaging and delivery towards gene expression and regulation. The NHG's are obtained from mixtures of N-isopropylacrylamide, acrylonitrile, di-block, and tri-block jeffamine macro-monomers in the presence of a cross-linker and radical initiator. The mechanism of NHG formation includes the formation of a self-assembly obtained by heating the thermo-responsive monomer's mixture. The final size of the final NHG is dictated by the size of the intermediary self-assembly. Sizes are tuned by combining different ratios of the starting monomeric mixtures which upon heating form self-assemblies of varied sizes. Initiator is then added at high temperature and the polymerization gives place to the formation of NHGs. The obtained NHGs were chemically reduced to lead particles with highly positive zeta potential and low cell toxicity. The obtained reduced NHG's were extensively characterized including DLS, zeta potential, FTIR and AFM. The NHGs are highly biocompatible and can complex pDNA to form polyplexes devoid of cell toxicity as assessed by XTT assays. The in-vitro result reveals that the polyplex complexes have the ability of long-term gene expression. The in-vivo intramuscular and subcutaneous administration shows a delayed but prolonged expression of the marker gene. The new platform might be applied to vaccination, since it will certainly better protect nucleic acids and allow longer expression of the antigenic protein for more efficient vaccination.



THERMOPLASTIC SEGMENTED POLYURETHANE/POLY(L-LACTIDE) BLEND AS DRUG-ELUTING DELIVERY SYSTEM

Adel Penhasi, Israel Baluashvili, Sondos Zgayar, Shiyam Edres,
Deborah Shalev¹

*Wolfson Centre for Applied Structural Biology, The Hebrew
University of Jerusalem, Jerusalem, Israel*

Polymers that have high moduli of elasticity have the necessary mechanical properties for drug-releasing implants that must sustain prolonged and consistent stress. Choosing polymers for this purpose is challenging due to stringent requirements, including biocompatibility, specific mechanical properties, and controlled drug release capabilities, within the limitation of FDA-approved polymers.

A series of composite polymers was developed by combining a high-modulus thermoplastic segmented polyurethane (TSPU) and poly(L-lactide) (PLLA). These polymers are immiscible, yet they remained compatible at all weight ratios without the need for a compatibilizer or plasticizer, although they showed reduced compatibility when weight ratios were nearly equal. The mechanical attributes and elasticity-load recovery of these blends were largely governed by the relative ratios of the component polymers [Penhasi, et al. *J. Appl. Polym. Sci.* 2020, **137**, 49517].

The antidiabetic drug tolbutamide was used as a model within a blend film of 80% TSPU and 20% PLLA for release studies and to determine the partitioning behavior into the two phases. The dispersed phase spontaneously organized into microspheres within the continuous phase in the presence of large amounts of tolbutamide. A comprehensive analysis of the composite polymer with and without the drug was conducted using DSC (differential scanning calorimetry), tensile testing, FTIR (Fourier-transform infrared spectroscopy), SEM (scanning electron microscopy), and transmitted light microscopy.

The 80% TSPU:20% PLLA polymer blend had a lower modulus at high drug load and an extended-release profile upon dissolution. Approximately half the drug eluted over 48 hours and the matrix itself showed 8% degradation in weight over 10 weeks. This immiscible-compatible system may be considered for use in drug-eluting, implantable drug-delivery systems.



UNLOCKING NEXT-GEN POLYOLEFIN DEGRADATION BY HEAT-RESISTANT DOUBLE EMULSIONS

Antolin Jesila Jesu Amalraj¹

Food science, Volcani Institute, Rishon leTzion, Israel

Our project aims to revolutionize spore encapsulation within emulsions, enhancing heat resistance to ensure spore viability amidst plastic hydrolysis. Utilizing O/W/O emulsions, we combine paraffin oil and an aqueous phase stabilized with hydrophilic and hydrophobic silica, achieving exceptional encapsulation efficiency (96.5%) of 6-micron *Conidia* spores in droplets of 10 μm and 124 μm . Visual confirmation through Confocal 2D/3D, SEM, and Cryo-SEM images verifies spore encapsulation in both single and double emulsions. Viability tests reveal a noteworthy 12% retention of colony-forming units (CFU) even after 100 days. Our milestone achievement involves successfully extruding emulsion-spore blends with LDPE, ensuring survival of emulsion droplets and encapsulated spores at 120°C, attributed to the remarkable structural stability and viscoelastic properties of the O/W/O emulsion. We initially selected fungal spores for the pilot formulation due to their ease of experimentation. Subsequently, we transitioned to bacteria, the actual plastic degrader, within the system to achieve our goal where the degradation of polyolefin was confirmed through FT-IR analysis. This breakthrough not only introduces a novel spore encapsulation method but also presents a groundbreaking approach to spore preservation during plastic processing, promising transformative impacts across various industries.



Session 2B: Composite materials

Invited Lecture

WHAT CAN WE LEARN FROM NATURE'S SOFT COMPOSITE MATERIALS?

Mirit Sharabi¹

*Department of Mechanical Engineering & Mechatronics, Ariel
University, Ariel, Israel*

Over millions of years of evolution, biological soft fibrous materials, such as soft tissues, have developed intricate structural mechanisms that enable exceptional mechanical performance, especially in enduring large deformations. These tissues are composite materials of repeating building blocks with diverse structural motifs, including variations in fiber fraction, orientation, multi-scale hierarchy, crimping, and weak interfaces. The exceptional properties of soft tissues arise from their intricate structural complexity. While the relationship between structure and function in nature's hard materials was extensively studied, soft materials have yet to receive similar attention despite their vast prevalence in nature.

Our approach involves creating new biomimetic composite materials by combining silk and collagen fibers with hydrogels using weak interfaces with reversible interactions. We reverse-engineered different structural motifs step-by-step to allow a toolbox that includes the isolated mechanical effect of the different motifs, such as the fiber fraction and orientation, crimping, and multi-scale hierarchy. Moreover, we generated dedicated 3D hyperelastic and heterogeneous finite-element models to simulate the mechanical behavior of the composite laminates under physiological conditions. Our materials display hyperelastic and anisotropic behaviors, showing large deformations, including distinct regions like toe, heel, and linear regions, together with multifunctionality and morphing abilities. Furthermore, by manipulating various structural features, we've successfully customized a wide array of mechanical behaviors.

Through reverse biomimetics applied to simpler materials, we can gain a deeper understanding of the intricate structure-function interplay in complex fibrous soft materials. This knowledge will aid in designing next-generation materials with tailored mechanical behaviors for diverse polymeric applications, leading toward a genuine leap in the realm of future soft composites.



Invited Lecture

**NOVEL EPOXY COMPOSITIONS FOR COMPOSITE MATERIALS -
MATERIALS AND PROCESSES**

Naum Naveh¹

*Department of Polymer Materials Engineering, Shenkar -
Engineering. Design. Art, Ramat Gan, Israel*

Novel solvent-less, "hot melt" toughened epoxy compositions and the resulting carbon/epoxy composites will be described.

The epoxy compositions are solid at room temperature, yet soften after heating, such that at the processing temperatures they behave like a liquid. They can impregnate either fiber tow or fabric, as resin or film, for later use in AFP/ATL, vacuum bagging, as film adhesive, etc.

Among the advantages of these compositions:

- The hot melts are solventless
- Extended outlife
- Can be transported and kept at moderately low temperatures or at room temperature, no need for freezing (-18°C) conditions
- Out-of-autoclave processing
- Tunable T_g from ~ 100°C to 200°C
- High composite toughness without rubber or thermoplastic additives
- Commercially available components
- Versatility: either bulk or film



MODIFYING THE PROPERTIES AND PERFORMANCE OF BIODEGRADABLE POLYMERS WITH ATOMIC LAYER DEPOSITION

Gil Menasherov¹

Department of Chemical Engineering, Technion - Israel Institute of Technology, Haifa, Israel

Degradable polymers offer a viable solution to the harmful environmental impact of conventional, non-degradable plastics. However, their widespread adoption is impeded by their lower performance compared to conventional polymers. Degradable polymers are often sensitive to elevated temperatures, UV radiation, and exposure to solvents, as well as have poor mechanical properties and high oxygen and water permeability (Nakajima, Dijkstra, and Loos 2017). One potential avenue for overcoming these challenges lies in the development of organic-inorganic hybrid materials. Vapor phase processes, such as sequential infiltration synthesis (SIS) - a method derived from atomic layer deposition (ALD), have emerged as a promising technique for synthesizing hybrid materials. In SIS, polymers are exposed to gaseous precursors that diffuse and interact with the polymers, leading to growth of inorganic materials within the polymer matrix (Leng and Losego 2017).

This research aims to modify degradable polymers, including poly(lactic acid) (PLA) and poly(hydroxyalkanoates)(PHA), using SIS to create hybrid materials with enhanced properties.

First we investigated the growth of AlO_x within and on top of PLA and PHA thin films and explored the precursor-polymer interactions using in-situ quartz crystal microbalance (QCM) microgravimetric measurements and electron microscopy. This fundamental understanding was further applied in finding the favorable conditions for SIS processes on 3D printed models of PLA and PHA. The hybrid AlO_x -polymer showed improved properties such as resistance to solvent vapors. These findings contribute to the development of environmentally friendly materials by harnessing the potential of SIS to enhance the properties of degradable polymers, thus addressing the global plastic accumulation problem.



ALLOY NANOWIRE ARRAYS WITH CONTROLLED COMPOSITIONS TEMPLATED BY BLOCK COPOLYMERS

Ofer Burg¹, Roy Shenhar¹

*Institute of Chemistry and the Center for Nanoscience and
Nanotechnology, The Hebrew University of Jerusalem, Jerusalem,
Israel*

Metallic nanowire arrays are promising components for nanotechnology thanks to their directional, continuous, longitudinal structure. Nanowires made from alloys of two or more metals are beneficial for applications such as catalysis and magnetism. The alloy composition influences the properties of the nanowires, and certain metal ratios show improved properties compared to their individual constituents. Yet, creating these nanowire arrays requires enhanced control over their composition and organization. This requirement may be answered by using block copolymer films, which provide three advantages: (a) they exhibit periodic arrays with typical periodicities of a few tens of nanometers; (b) the domains could be aligned using patterned substrates; (c) impregnation of the films with metal precursors and subsequent plasma treatment affords metallic nanowires that are organized in periodic arrays.

In this work, we use films of polystyrene-block--poly(2-vinylpyridine) to create arrays of alloy nanowires with controlled compositions. We achieve this control by studying how different impregnation parameters affect the amount of metal in the nanowires and the metal ratio in alloys. Namely, impregnating the film with palladium precursors, followed by platinum precursors for different durations, shows how one metal increases over the other, and the rate of metal precursor replacement in the film. Additionally, impregnating with a mixture of palladium and platinum precursors in different ratios gives different Pd-Pt alloys, and elucidates the affinity of each metal to the film. These experiments give an understanding of the interaction between the metal precursors and the pyridine groups in the polymer and lay a foundation for fabricating alloy nanowires with controlled compositions.



ADDITIVE MANUFACTURING OF GRAPHENE-BASED COMPOSITES WITH DIAMONDS AS HIGH-VOLUME FILLERS

Shani Ligati Schleifer¹, Oren Regev^{1,2}

¹*Department of Chemical Engineering, Ben-Gurion University of the Negev, Beer Sheva, Israel*

²*The Ilse Katz Institute for Nanoscale Science and Technology, Ben-Gurion University of the Negev, Beer Sheva, Israel*

The use of additive manufacturing (AM) for the rapid, facile creation of complex structures could provide thermal management solutions in the form of heat sinks and heat exchangers with high surface areas that facilitate heat dissipation. To prepare a heat sink with high thermal conductivity (TC), we use vat photopolymerization (VPP) of a polymer-based composite material with a low TC that is enhanced by loading with a graphene-based thermally conductive filler. Phase separation of the carbon-based filler, in this case, graphene nanoplatelets (GNP), in the monomer printing solution is prevented by stabilizing the GNPs by the addition of a second fiber-like clay (sepiolite) filler, which traps the GNPs. This methodology enables the AM of a composite with a relatively high GNP concentration of 2.0 wt%, yielding a TC enhancement of 160% vs. the pristine polymer—an impressive accomplishment for VPP 3D printing. The addition of a high-volume filler (HVF) is suggested to further enhance the printed composite properties. The HVF was identified as a means of further improving the properties of the composite since the HVF occupies a larger volume, thereby allowing the GNPs to spread in a smaller volume and increase their effective concentration. Here, the HVF chosen is diamonds, possessing high TC and mechanical strength, which resulted in further enhancement of the TC and the fracture toughness only when accompanied by the GNP. The developed VPP 3D-printed composites could be applied in thermal management systems made of lightweight and cost-effective materials.



TECHNOLOGICAL SYNERGY: INTEGRATION OF POLYMERS AND CERAMICS IN DESIGN, THROUGH ADVANCED PROCESSES

Ira Shtein Rozenman¹

Master in Design, Shenkar - Engineering. Design. Art, Ramat Gan, Israel

This presentation provides a detailed examination of the nuanced relationship between polymers, ceramics, and design. The focus is brought on their integration within advanced manufacturing processes for injection molding and FDM 3D printing.

Polymers, known for being versatile and processable, have been long favored in design applications. Ceramics, known for being durable and tough, bring added value to the design world. Nowadays, when it comes to designing things, the fusion of different materials and technologies is a strong driver for innovation. The challenge is to create products with enhanced material characteristics, and structural integrity. This challenge and aesthetic appeal drive designers and engineers to explore novel possibilities.

4 main sections will be presented. First, different aspects of how a dry blend of polymers and ceramics can be produced. Second, practical examples will be provided to demonstrate successful applications of polymer-ceramic mix using technological methods like injection molding and 3D printing. Thirdly, several design examples of ceramic products will be presented. Finally, one product design will be used as a case study review for material/technology/design synergy.

To summarize, this presentation shines a light on the synergy between materials, technology, and design. It shows how working with a multidisciplinary approach leads to new and exciting possibilities in the world of advanced manufacturing.



Israeli Polymers & Plastics Society (IPPS)

The 50th Conference of The Israeli Polymers & Plastics Society

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Session 1C:

Functionalized Polymers

Invited Lecture

FACILE ONE-STEP SYNTHESIS OF WATER-SOLUBLE CELLULOSE ACETATE

Yachin Cohen¹, Dmitry M. Rein¹, Gilad Alfassi²

¹*Chemical Engineering, Technion - Israel Institute of Technology, Haifa, Israel*

²*Biotechnology Engineering, Braude College of Engineering, Karmiel, Israel*

Cellulose is the oldest and most abundant natural polymer. Its compact crystal results in recalcitrance towards dissolution and hence functionalization. Nevertheless, cellulose acetate (CA), the oldest synthetic polymer, is an important cellulose derivative. Water-soluble cellulose acetate (WSCA) is a useful functional polymer. Moreover, it is a substrate for many interesting further functionalizations. However, WSCA synthesis requires first full acetylation of all 3 hydroxyls on every anhydroglucose unit (AGU) followed by hydrolysis to a degree of substitution (DS) ~ 1-2. The DS controls its water solubility, and the reason why “hydrophobization” of cellulose is required to render it water soluble is fascinating in itself. This work describes a simple one-step synthesis of WSCA by its dissolution in an ionic liquid (IL) 1-ethyl-3-methyl imidazolium acetate (EMIMAc) mixed with dichloromethane (DCM). This yields homogenous acetylation by nucleophilic displacement of the DCM chloride with the IL acetate ion yielding methylene diacetate or chloromethyl acetate which derivatizes the AGU hydroxyls. The degree of substitution was controlled by the DCM content, to maximal acetylation at DS of 1.9. Small-angle x-ray scattering from aqueous WSCA solutions showed full molecular dissolution with no sign of aggregates, and revealed a semi-rigid chain conformation with a very large persistence length, over 10 nm. The WSCA exhibited surface activity, significantly reducing the surface tension of water. This method provides facile synthesis of a valuable amphiphilic polymer, from sustainable biomass resources, which is also a useful platform for further functionalization in non-hazardous and environmentally friendly aqueous solution.



Invited Lecture

POLYMERIC ARCHITECTURE AS TOOL FOR PROGRAMMING TRANSFORMABLE MATERIALS

Roey Amir^{1,2}

*School of Chemistry, Tel Aviv University, Tel Aviv, Israel
The ADAMA Center for Novel Delivery Systems in Crop Protection,
Tel Aviv University, Tel Aviv, Israel*

Supramolecular assemblies in nature can adopt different structures and functions, which allows them to perform intricate biological tasks. Inspired by this ability to respond to different cues in the environment, stimuli-responsive polymeric amphiphiles have emerged in the past two decades. However, most reported systems have been able to transition only between two states, such as from assembled to disassembled states or between two assembled mesophases. Enzyme-responsive polymers have become highly promising area for potential applications in biomedicine. Similar to other stimuli-responsive systems, enzyme-responsive assemblies have mostly been designed to undergo a single transition, with limited examples of polymers that can undergo multiple transitions between several mesophases by incorporating two (or more) different types of responsive units into the polymeric system.

In this talk, we will present a new modular approach for programming polymeric assemblies to undergo several sequential mesophase transitions using macromolecular architecture as the programming tool. Taking advantage of the different kinetic stability of amphiphilic di- and tri-block copolymers, we were able to program polymeric formulations to transition from micelles into polymeric hydrogels, followed by a transition into soluble polymers in response to a single type of activating enzyme. Furthermore, we demonstrate the ability to tune the time frame of the mesophase transitions by adjusting the structures and ratio of the two amphiphiles. The utilization of macromolecular architecture as a programming tool opens new directions for designing polymeric systems capable of adopting different structures to fulfill complex functional tasks.



Invited Lecture

SALT DEPENDENT BEHAVIOR AND PROPERTIES OF METHYLCELLULOSE SOLUTIONS

Lucy Liberman¹

*The Wolfson Faculty of Chemical Engineering, Technion – Israel
Institute of Technology, Haifa, Israel*

Methylcellulose (MC) is a commercially important water-soluble polysaccharide, which thermoreversibly gels upon heating. Although MC has been studied and exploited in applications for many decades, it has only recently been discovered that the gelation occurs via self-assembly of the polymer chains into ca. 15 nm diameter fibrils, which percolate into a network. The network structure dictates the properties and mechanical behavior of the resulting hydrogel. The addition of salt to MC gels has been an area of academic and commercial interest. MC solutions containing salts exhibit an increase or decrease in the gelation temperature, generally following the Hofmeister series. We build upon those investigations and explore the effect of salt on MC structure and properties in solution. We demonstrate the effect of added salt on gelation, dissolution temperatures, and gel modulus using rheology. From small angle X-ray scattering (SAXS) and cryogenic transmission electron microscopy, we show that salty MC gels are also comprised of fibrils. Fitting the SAXS curves to a semiflexible cylinder model, we demonstrate that the fibril diameter decreases monotonically with increasing salt molarity, largely independent of the salt type. We propose two different mechanisms of fibril diameter reduction with the addition of salt.



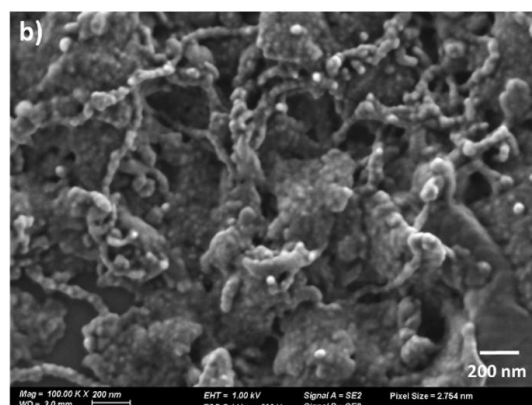
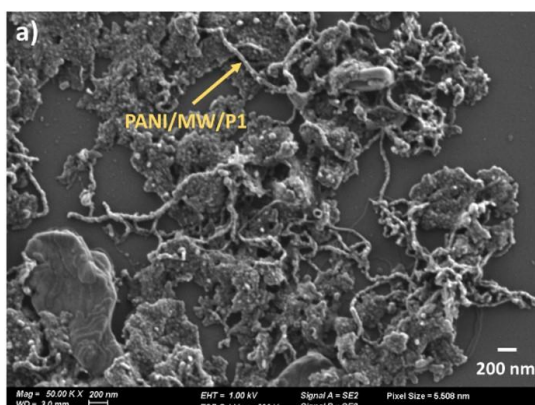
Invited Lecture

Development and Characterization of Integrated Nano-Sensors for Organic Residues and pH Field Detection

Ran Suckeveriene¹

Water Industry Engineering Department, Kinneret Academic College, Zemach, Israel

Meeting global water quality standards is a real challenge to ensure that food crops and livestock are fit for consumption, as well as for human health in general. A major hurdle affecting the detection of pollutants in water reservoirs is the lapse of time between the sampling moment and the availability of the laboratory-based results. Here, we report the preparation, characterization, and performance assessment of an innovative sensor for the rapid detection of organic residue levels and pH in water samples. The sensor is based on carbonaceous nanomaterials (CNMs) coated with an intrinsically conductive polymer, polyaniline (PANI). Inverse emulsion polymerizations of aniline in the presence of carbon nanotubes (CNTs) or graphene were prepared and confirmed by thermogravimetric analysis and high-resolution scanning electron microscopy. Aminophenol and phenol were used as proxies for organic residue detection. The PANI/CNM nanocomposites were used to fabricate thin film sensors. Of all the CNMs, the smallest limit of detection (LOD) was achieved for multi-walled CNT (MWCNT) with a LOD of 9.6 ppb for aminophenol and a very high linearity of 0.997, with an average sensitivity of 2.3 k Ω /pH at an acid pH. This high sensor performance can be attributed to the high homogeneity of the PANI coating on the MWCNT surface.





Invited Lecture

**TBA ENGINEERING LINEAR AND CROSSLINKED NANOPARTICLES
DUAL FUNCTIONALIZED URACIL AND HYDANTOIN-BASED
ANTIVIRAL/ANTIMICROBIAL POLYMERS**

Eid Nassar-Marjiya

*Farah Laboratory for Advanced Functional/Medicinal Polymers & Smart Drug
Delivery Technologies, Technion - Israel Institute of Technology, Haifa, Israel*

Pandemics, such as Covid-19 recently, have claimed millions of lives globally. Surface contamination is one prominent route that spreads the viruses, specially in public areas. Thus, the need to synthesize efficient disinfectants to protect these surfaces from viral transmission is highlighted, which inturn lies on small molecule-based surface decontamination. In this work, we are focussing on utilizing polymers by synthesizing new antiviral oligomers with n-halamine and quaternary ammonium functionalities as long-lasting disinfecting materials. The most active oligomers showed better antiviral activity as compared to household bleach, with over 99.8% effectiveness against SARS-CoV-2 at far lower concentrations (< 3% bleach).

Furthermore, the active materials unveil rapid viral deactivation and sustained efficacy against viruses on a variety of surfaces, while exhibiting no harm to human cells. Thus, these polymers are promising effective disinfectant alternatives for future pandemics.



Session 2C:

Bioinspired and biodegradable polymers

Invited Lecture

NEW BIODEGRADABLE MATERIALS BASED ON NATURE-SOURCED POLYSACCHARIDES

Elena Poverenov

Postharvest and Food Sciences, Department of Food Science, Volcani Institute, Rishon LeZion, Israel

Nature-sourced biodegradable polymers can be utilized as active films, coatings and delivery systems. Such materials respond to customer demands for safe and healthy approaches and satisfy environmental concerns. Among biopolymers, polysaccharides are considered particularly promising candidates since they are sustainable, safe, and hypoallergenic materials that are also abundant and inexpensive. An important advantage of polysaccharides is that their defined chemical structure allows rational modification and precise tuning of their properties. We utilize covalent modifications and non-covalent approaches (sonochemical deposition, layer-by-layer design, nanoemulsification) to control physicochemical properties and functionality of the resulted biodegradable materials. In this lecture, we will present delivery systems based on modified polysaccharide derivatives that could encapsulate molecular cargoes of various polarities (from highly hydrophobic to ionic compounds) in aqueous and lipid environments and transport them through biological barriers, opening up numerous potential applications in various fields such as medicine, cosmetics, food and agriculture. In addition, we will present, polysaccharide-based active films and packages that can be used in food, agriculture and other applications.

Finally, we will be presented polysaccharide-based edible coatings that can protect food products from physical, mechanical and microbial damages.



Invited Lecture

BIOINSPIRED MATERIALS FOR BIOMEDICAL APPLICATIONS

Lihl Adler-Abramovich¹

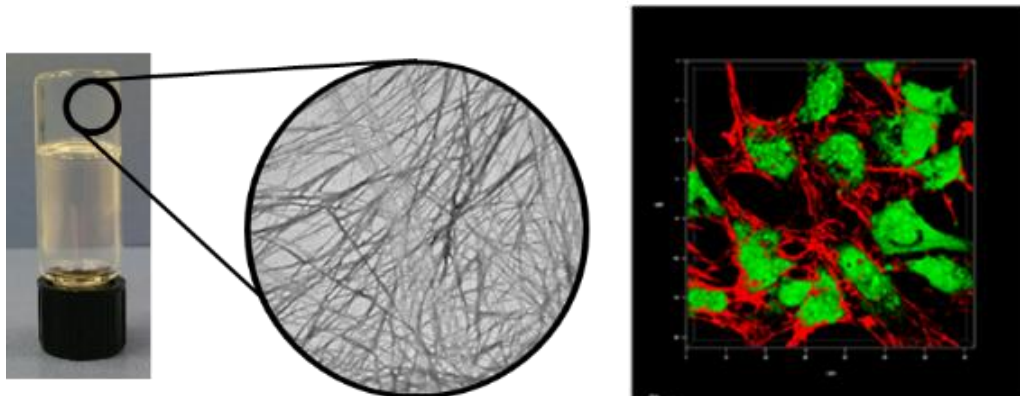
Department of Oral Biology, The Goldschleger School of Dental Medicine, Faculty of Medicine & Health Sciences, The Center for Nanoscience and Nanotechnology, Tel Aviv University, Tel Aviv, Israel

The emerging demand for tissue engineering scaffolds capable of inducing bone regeneration using minimally invasive techniques prompts the need for the development of new biomaterials. One promising route is molecular self-assembly, a key direction in current nanotechnology and material science. In this approach, the physical properties of the formed supramolecular assemblies are directed by the inherent characteristics of the specific building blocks. Molecular co-assembly at varied stoichiometry substantially increases the structural and functional diversity of the formed assemblies, thus allowing tuning of their architecture and physical properties.

Here, in line with polymer chemistry paradigms, we applied a co-assembly approach using hydrogel-forming peptides, resulting in a synergistic modulation of their mechanical properties to form extraordinarily rigid hydrogels that supported osteogenic differentiation based on cells-mechano-sensing. Furthermore, we designed a multi-component scaffold composed of polysaccharides, short self-assembling peptides, and bone minerals. We demonstrate the formation of a rigid yet injectable and printable hydrogel without the addition of cross-linking agents. The formed composite hydrogel displays a nanofibrous structure, which mimics the extracellular matrix and exhibits thixotropic behavior and a high storage modulus. This composite scaffold can induce osteogenic differentiation and facilitate calcium mineralization.

This work provides a conceptual framework for utilizing co-assembly strategies to push the limits of nanostructure physical properties obtained through self-assembly to

design new biomaterials for tissue engineering and personalized medicine applications.



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BIOPLASTIC MATERIAL BASED ON ETHYL CELLULOSE

Eden Shlush¹, Maya Davidovich-Pinhas¹

*Department of Biotechnology and Food Engineering, Technion –
Israel Institute of Technology, Haifa, Israel*

The extensive usage of conventional plastics leads to resource depletion and massive waste accumulation. The growing awareness of these deleterious effects has resulted in development of new and sustainable bioplastics. The current research aims to exploit ethyl-cellulose (EC), bio-based biopolymer, to fabricate biodegradable bioplastic films using hot-melt processing and examine their performance.

The extrusion process seems to reduce the biopolymer molecular weight and crystallinity as confirmed by gel permeation chromatography tests and thermal analysis. The thermal analysis also showed lower T_g and T_m for all plasticizers, confirming their activity. Additionally, all plasticizers led to thermoplastic mechanical behavior characterized by elastic and plastic deformation, as opposed to solely elastic behavior of the neat EC film, confirming their mechanical plasticizing effect. The plasticized films exhibited significantly higher tensile strength and percent of elongation at break, resulting in stronger and more flexible films. Surprisingly, the water contact angle measurements revealed hydrophilic nature, which was supported by the water vapor permeation tests. EC-based films showed relatively high permeability to water vapor and oxygen, signifying their suitability as packaging material for fresh produce. Microscopy imaging did not reveal any significant difference between EC films, suggesting that the plasticizers were miscible with EC and evenly distributed in the films. Furthermore, biodegradability tests confirmed that certain cellulases can decompose EC films.

This study demonstrates the feasibility of forming EC-based films with tunable properties using hot-melt processing with different plasticizers that can be used in diverse applications, which strengthen the significance of EC as a sustainable bioplastic material.



DEGRADABLE POROUS POLYESTERS VIA EMULSION-TEMPLATING: SYNTHESIS, PROPERTIES, 3D PRINTING, AND CELL GROWTH

Bar Shlomo-Avitan, Samah Saied Ahmad, Yoav Friedler, Hila Toledo, Michael Silverstein

PolyHIPEs are highly porous, emulsion-templated polymer monoliths typically synthesized via free radical polymerization within high internal phase emulsions (HIPEs), emulsions with more than 74 vol % internal phase. The unique qualities of polyHIPEs and the ability to tailor them through variations in the synthesis procedure make them suitable for the development of novel three dimensional scaffolds for such applications as drug delivery and tissue engineering. The objectives of this research were to synthesis and develop polyHIPEs containing biodegradable and biocompatible macromonomers (macromers) and to investigate the effects of macromer type on the polyHIPE structure and properties. Specifically, the polyHIPEs were based on methacrylated oligomeric biodegradable polyesters: poly(ϵ -caprolactone) (PCL), polylactide (PLA), and poly(lactide-co-glycolide) (PLGA), copolymers of lactide and glycolide. PolyHIPEs based on the ring-opening polymerization (ROP) of lactide and glycolide with molecular weights of ~ 2200 g/mol exhibited densities between 0.10 and 0.13 g/cc. While polyHIPEs based on PCL triol oligomers of different molecular weights, from 530 to 2000 g/mol, exhibited densities between 0.18 and 0.28 g/cc, they all degraded to completion at similar rates within 2.5 h in 3 M NaOH. 3D printing was successfully used to produce objects from a HIPE containing methacrylated oligomer, either a PCL diol or a PLA triol. This work demonstrated that objects with potential for cell growth can be printed from HIPEs based on methacrylated polyester macromers.



A NOVEL HOT-MELT BIODEGRADABLE TISSUE ADHESIVE FOR BONE FRACTURE REPAIR

Orel Shem Tov¹, Anna Dotan¹, Dan Lewitus¹

*Department of Polymer Materials Engineering, Shenkar College,
Ramat-Gan, Israel*

Biodegradable bone adhesives for fracture repair can be an effective alternative to metallic implements to stabilize the bone fracture, promote healing, and restore full function and mobility. Nonetheless, achieving strong adhesion to the bone is complex under physiological conditions. Herein, a polymer-based hot melt biodegradable bone-tissue adhesive was developed for bone fracture repair to provide strong bone adhesion in physiological (wet) conditions and is easy to apply. The incorporation of 3,4-dihydroxyhydrocinnamic acid (HCA) and monobasic calcium phosphate monohydrate (MCPM) into the poly(ϵ -caprolactone) (PCL) matrix via melt blending, demonstrated successful adhesion of bovine bone slices under wet conditions. Utilizing a mixture design of experiments with JMP[®] software to optimize the adhesive formulation to maximize adhesion strength while minimizing the melting temperature. The optimized composition has a melting temperature of $52 \pm 0.6^\circ\text{C}$ and a lap shear adhesion strength of 0.29 ± 0.09 MPa after 30 min and 0.23 ± 0.05 MPa after 2 hr. of solidification under physiological conditions. The hotmelt adhesive represents a promising approach toward bone fraction repair.



Session 1D: Sustainability Solutions in the Plastic Industry

Invited Lecture

CAN WE MAKE A RECYCLED MATERIAL EQUIVALENT TO PRIME?

Shiran Garnai Hirsch¹, Yoav Shay¹, Oz Gazit²

¹*Global Materials R&D and Technologies, Netafim LTD, Magal, Israel*

²*Department of Chemical Engineering, Technion - Israel Institute of Technology, Haifa, Israel*

The exceptional properties of Polyethylene (PE) such as thermal and chemical stability combined with its good processability make PE one of the most extensively used synthetic polymers. However, PE's advantageous properties also prevent its biodegradation, which results in the formation of huge amounts of post-usage waste. Efforts towards mitigating negative environmental effects are driving a growing demand to extend the service life of PE-based products and to increase the use of recycled PE. Despite PE's high durability, it is still susceptible to weathering, resulting in significant deterioration of its chemical and mechanical properties. To understand and control these negative effects and prevent material failure much work was done to characterize the photo-degradation process of PE. Understanding the kinetic changes in photo-oxidative decomposition may underline practical methods for enhancing the endurance of waste PE.

Using modulated thermogravimetry analysis (MTGA) to monitor the kinetics of PE decomposition we previously uncovered that the extent of weathering is correlated to the energy needed to initialize the volatilization of molecular fragments from within the polymer framework. To describe the value of the activation energy first appearance, we coined the term 'volatilization energy onset', designated as E' .

In this work we use our understanding of E' to compare the weathering effect of a prime and recycled materials. We find that the MTGA method and the E' values correctly describe the weathering effect various sources of recycled materials, which come in different colors, state and contain additives of different types and amounts. Selecting representative waste PE sources (i.e. post-consumer, post-industrial and post-agriculture) we analyzed the effect of the change in PE properties with and



without additional additives. We find that by an appropriate and accurate stabilizing package, even the most highly degraded waste PE can be made to function as well as a prime PE. This outstanding data is crucial our environment as it provides for all companies using recycled materials from external sources the ability to reincorporate recycled PE with confidence.



Invited Lecture

THE ROAD TO TÜV BIODEGRADABILITY CERTIFICATION

Moira Nir¹

R&D Department, Solutum Technologies, Ltd., Tel Aviv, Israel

At Solutum we develop novel biodegradable water-soluble formulations for packaging materials.

Biodegradable materials that meet defined standards are eligible for biodegradability certification by recognized organizations such as TÜV in Europe.

The long, involved road from materials design to testing to TÜV certification will be described for our leading commercial product. Results from in-house and external biodegradation tests and associated procedures will be presented.



Invited Lecture

CONVERTING AGRICULTURAL PLASTIC WASTE INTO VALUE-ADDED COMPOSITE MATERIALS

Jenny Goldman¹, Rotem Shemesh¹, Michael Gishvoliner¹, Anna Dotan², Shy Adar Lev-Or³, Yori Costa³

¹*R&D, Carmel Olefins, Haifa, Israel*

²*Department of Plastics Engineering, Shenkar - Engineering. Design. Art, Ramat Gan, Israel*

³*R&D, Tama, Kibbutz Mishmar HaEmek, Israel*

Recycling poses a significant challenge when it comes to agricultural plastic waste that contains both organic and inorganic residues. The cost-effective cleaning of this waste is impractical, leading to the majority of this waste being disposed of in landfills or incinerated. Our suggestion involves using this waste to create a new composite material that exhibits enhanced characteristics. The desirable product is a thermoplastic composite that is reinforced by natural fibers and comprises a minimum of 50% agricultural waste. The distinctive features of this composite include its low density due to the lighter nature of cellulose fibers compared to materials like glass fibers. It also exhibits a high elasticity modulus, tensile strength, fair impact resistance, heat resistance (HDT) exceeding 120 °C, suitability for processing through injection molding and extrusion, lack of strong odor, and a comparatively affordable cost. This composite has the potential to be employed in a variety of products, spanning from automobile components and outdoor furniture to storage facilities, electrical devices, construction materials, etc. Conducted experiments demonstrate the practical viability and attractive characteristics achievable through the utilization of this composite.

These products possess a distinct environmental benefit since they originate from agricultural waste, unlike the current alternatives which involve using WPC (wood plastic composites) sourced from designated crops. These alternatives demand agricultural land usage, fertilizer application, freshwater consumption, associated costs, and other expenditures. In contrast, the proposed solution solely necessitates waste collection and basic cleaning.



RECYCLED RUBBER POWDER FROM END OF LIFE TIRES AS A FUNCTIONAL FILLER AND ADDITIVE IN POLYOLEFINES - A CIRCULAR ECONOMY APPROACH

Eynat Matzner¹, Nataly Vainrot¹
R+D, Tyrec Ltd, Shahak Industrial Zone, Israel

Tyrec has been recycling End of Life Tires since 2007. Worldwide ELT are a major concern with about 1 billion tires reaching their end of life every year, numbers that are not expected to decrease in the foreseeable future.

More than half of ELTs are still burned for energy and landfill is still a major concern.

Tyrec has developed a new and innovative use for ELT, by producing fine rubber powders, with controlled particle size and coatings, suitable as a filler and additive to the plastic industry.

The fine rubber powder can replace 10%- 30% of the polymer in plastic products in a truly circular economy. It is introduced into plastic products easily as specially developed granules.

The use of recycled rubber powder in plastics is bringing a new and stable source of raw materials to the industry and is a competitive and sustainable solution.

Tyrec rubber granules have been developed to perform as an impact modifier, already demonstrated in production environment with polypropylene and polyethylene formulations.

Even that the powder is black, it has been demonstrated that colored products can be produced.

The properties of Tyrec fine recycled rubber powder in polyolefines will be discussed in depth, including potential applications



ENVIRONMENTAL IMPACT DIFFERENCES IN BATCH AND FLOW CHEMISTRY: CASE STUDY OF SINGLE-CHAIN NANOPARTICLE PRODUCTION

Or Galant¹, Charles E. Diesendruck², Sabrina Spatari¹

¹*Department of Environmental and Civil Engineering, Technion - Israel Institute of Technology, Haifa, Israel*

²*Schulich Faculty of Chemistry, Technion - Israel Institute of Technology, Haifa, Israel*

Emerging nano-scale materials are under development for multiple high-performance product applications such as advanced polymers. Single chain polymer nanoparticles (SCNPs) have many promising high-performance uses in catalysts, lubricants, nanoreactors and biomedical applications; however, synthetic routes to SCNPs are still under development and usually require an excessive amount of solvent, imposing costly environmental impacts.

In this research, prospective life cycle assessment (LCA) methods is applied to evaluate alternative SCNPs synthesis routes through a photochemistry process where the role of limiting solvent quantity and type used are examined. SCNPs production is compared through a flow photochemical process versus a classical batch process. Using a cradle-to-gate system boundary, the performance of different batch and flow processing scenarios are compared, considering solvent recovery through vacuum distillation, atmospheric distillation, and solvent replacement and waste solvent treatment.

The results indicate that there are environmental benefits under the flow process over conventionally used batch processes where the solvent is recovered through atmospheric distillation, and toluene is the preferred solvent. In addition, the LCA results are compared to a common green chemistry metric known as the Environmental factor where it is shown that a green chemistry metric alone is insufficient. Hence, a comprehensive and systematic life cycle approach is needed to understand the environmental impacts of flow chemistry with potential scenarios prior to scaling up production.



HYDROTHERMAL DECOMPOSITION OF PLASTIC — VALORIZATION OF NON-RECYCLABLE MIXED PLASTIC WASTE

Ran Darzi¹, Yael Dubowski¹, Roy Posmanik²

¹*Department of Civil and Environmental Engineering, Technion - Israel Institute of Technology, Haifa, Israel*

²*Department of Water and Environmental Science, Newe Ya'ar Research Center, Agricultural Research Organization, Newe Ya'ar, Israel*

Plastic is a significant contributor to extensive environmental pollution. Currently, plastic is recycled by mechanical methods designed to treat mono-material streams. Multi-material plastics are ubiquitous in many sectors such as food packaging and agriculture. Re-extrusion of two (or more) incompatible polymers results in a low-quality product. The low recycling potential of inseparable polymers is due to mechanical recycling limitations and difficulties in sorting and separating such products. Hydrothermal processing (HTP) suggests a new platform to convert multi-material plastics into valuable products. Polyamides and polyesters were shown to decompose by HTP into their original monomers in subcritical water. For polyolefins, which are absent of heteroatomic bonds, depolymerization may occur at supercritical temperatures, typically 400°C. Leveraging existing knowledge, the current research examines plastic mixture valorization in sub-critical water (300°C; 10 MPa). Here, we will present the decomposition mechanisms of low-density polyethylene (LDPE), polyethylene-terephthalate (PET), and polyamide (PA), and the advantages of HTP for their mixtures. PET+PA mixture was converted into monomeric compounds (terephthalic acid and ϵ -caprolactam). Due to the different chemical properties and phase distribution of these products, a successful separation was achieved. LDPE+PA mixture was examined using multilayered agricultural mulching film. The treatment resulted in efficient monomer recovery from the PA layer, while the remaining solids were characterized as LDPE, suitable for successive processing routes. These results indicate the potential of HTP to achieve closed-loop recycling of plastic waste. Moreover, the novel technology can promote complex waste valorization, preventing landfilling of inseparable mixtures and moving towards a circular plastic economy.



Session 2D: Self-assembly in biomaterials

Invited Lecture

SELF-ASSEMBLY OF SHORT PEPTIDES AND AMINO ACIDS INTO FUNCTIONAL COATINGS

Meital Reches¹

*Institute of Chemistry, The Hebrew University of Jerusalem,
Jerusalem, Israel*

Short peptides and amino acids are promising building blocks for sustainable materials as they are non-toxic and biodegradable. In this lecture, I will present bio-inspired functional coatings that are spontaneously formed by extremely short peptides and commercially available amino acids. These coatings self-assemble on metals, oxides, and polymers under mild conditions without any need for a curing step and can serve many functions including self-cleaning and antifouling.¹ We specifically showed that extremely short peptides can self-assemble into a coating that prevents the first step of biofouling, which involves the adsorption of bioorganic molecules to the substrate. The coating significantly reduces the attachment of various organisms, such as bacteria, viruses and fungi, to surfaces.^{2, 3} Another function that these peptide-based coatings can mediate is the adhesion of mammalian cells to implants. This function is important for the integration of implants into the human body. Moreover, these peptides self-assemble in solution into particles that adsorb and release active compounds that synergistically reduce the number of bacteria, viruses and fungi.⁴ They can also be integrated into polymeric films by a simple co-extrusion protocol to form active polymeric films.⁵ Finally, we showed that an individual amino acid can self-assemble into a superhydrophobic coating that can provide surfaces with the ability to self-clean.⁶

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NITROGEN-RICH, POLYETHYLENEIMINE-BASED, INTERPENETRATING NETWORK POROUS MONOLITHS: SYNTHESIS AND APPLICATION

Dahiana Mayer-Keren¹, Michael S. Silverstein²

*¹Interdisciplinary Program in Polymer Engineering, Technion -
Israel Institute of Technology, Haifa, Israel*

*²Department of Materials Science and Engineering, Technion - Israel
Institute of Technology, Haifa, Israel*

Pollutant adsorption using amine-rich materials is a promising method to mitigate air and water pollution. Porous, amine-containing solid adsorbents are usually generated by physical impregnation or chemical grafting of polyethyleneimines (PEIs). These adsorbents can have high amino densities and adsorption capacities, but unfortunately, they exhibit poor regeneration performance due to PEI leaching. Highly porous, crosslinked PEI-based hydrogel monoliths whose amine groups are inherent parts of the framework would be advantageous for such applications. In addition, PEI can be combined with other polymers in interpenetrating polymer networks (IPN) to enhance crosslinking through network entanglement, and potentially, to enhance the mechanical behavior and adsorption. Amine-containing porous IPN monoliths with high porosities can be synthesized through polymerization within the external phase of an oil-in-oil (o/o) emulsion.

Highly porous monoliths (polyMIPes) with densities of around 0.13 g/cm^3 and coral-like structures were generated by templating within o/o medium internal phase emulsions containing PEI and bisphenol A diglycidyl ether (BPDE). PolyMIPes with superior mechanical properties, but with an inferior adsorption capacity for the anionic dye methyl orange, were synthesized by increasing the epoxy-to-amine ratio from 25 to 50%. On the other hand, polyMIPes based on acrylamide (AAm) crosslinked with N,N'-methylenebis(acrylamide) (MBAAm) exhibited the typical structure associated with emulsion templating (voids with an average diameter of $5.72 \mu\text{m}$ and interconnecting holes with an average diameter of $1.37 \mu\text{m}$) and had densities of around 0.15 g/cm^3 . PolyMIPes based on combining the PEI-BPDE and P(AAm-co-MBAAm) networks through simultaneous polymerizations had densities of around 0.16 g/cm^3 and coral-like structures. BPDE, used to form the PEI network, was critical for monolith stability; the monolith synthesized in the absence of BPDE crumbling during purification.



A SELF_HEALING MULTISPECTRAL TRANSPARENT ADHESIVE PEPTIDE GLASS

Gal Finkelstein-Zuta¹

Material science, Tel Aviv University, Tel Aviv, Israel

Glass is fundamental in diverse fields of materials science. However, engineering a glassy material without compromising its properties is a major challenge. Here, we report the discovery of a supramolecular amorphous glass formed by the spontaneous organization of short aromatic peptides initiated by noncovalent cross-linking of structural water. This unique system exhibits two, often contradicting, combinations of properties; it is highly rigid yet can undergo complete self-healing at room temperature. In addition, it is an extremely strong adhesive yet transparent in a wide spectral range from visible to mid-infrared. This exceptional set of properties is observed in a simple bioorganic peptide glass composed of natural amino acids, presenting a multi-functional material that could be highly advantageous for various applications in science and engineering.



LIQUID CO-POLYMERS AS BIODEGRADABLE SURGICAL SEALANT

Neta Shimony¹

*Department of Biotechnology and Food Engineering, Technion -
Israel Institute of Technology, Haifa, Israel*

Surgical sealants are widely used to prevent seepage of fluids and liquids, promote hemostasis, and close incisions. Despite the remarkable progress the field of biomaterials has undergone, the clinical uses of surgical sealants are limited because of their short persistence time in vivo, toxicity, and high production costs. Here, we present the development of two complementary neat (solvent-free) prepolymers, PEG4-PLGA-NHS and PEG4-NH₂, that harden upon mixing to yield an elastic biodegradable sealant. The mechanical and rheological properties and cross-linking rate can be controlled by varying the ratio between the two prepolymers. The tested sealants showed a longer persistence time compared with fibrin glue, minimal cytotoxicity in vitro and excellent biocompatibility in vivo. The neat, multi-armed approach demonstrated here improves the mechanical and biocompatibility properties and provides a promising tissue sealant solution for wound closure in future surgical procedures



BIOADHESIVE MICRONEEDLE PATCHES FOR TISSUE SEALING

Eden Freundlich

Faculty of Biotechnology and Food Engineering, Technion – Israel Institute of Technology, Haifa, Israel

Sealing of soft tissues prevents leakage of gas and liquid, closes wounds, and promotes healing and is, therefore, of great significance in the clinical and medical fields. Although various formulations have been developed for reliable sealing of soft tissue, tradeoffs between adhesive properties, degradation profile, and tissue toxicity limit their clinical use. Hydrogel-based adhesives, for example, are highly biocompatible but adhere very weakly to the tissue and degrade quickly, while oxidized cellulose patches are poorly absorbed and may cause healing complications postoperatively. Here, we present a novel strategy for tissue sealing based on bioadhesive microneedle patches that can spontaneously adhere to tissue surface through electrostatic interactions and swell within it. A series of microneedle patches made of pullulan, chitosan, Carbopol, poly (lactic-co-glycolic acid), and a Carbopol/chitosan combination were fabricated and characterized for their use in tissue sealing. The effect of microneedle composition on the fabrication process, physical and mechanical properties, in vitro cytotoxicity, and in vivo biocompatibility were examined. The needle structure enables microneedles to strongly fix onto various tissues via physical inter-locking, while their adhesive properties improve staying time and sealing capabilities. The microneedle patch comprising Carbopol needles and chitosan as a second pedestal layer presented the best results in terms of sealing and adhesion, a consequence of the needle's swelling and adhesion features combined with the supportive chitosan base layer. Finally, single Carbopol/chitosan patches stopped intense liver bleeding in a rat model significantly quicker and with less blood loss compared with commercial oxidized cellulose patches. These microneedles can be considered a promising cost-effective platform for adhering and sealing tissues as they can be applied quickly and painlessly, and require less trained medical staff and equipment.



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¹*Plant Science, Volcani Institute, Rishon Le-Zion, Israel*
²*Agriculture Faculty, The Institute of Biochemistry, Food Science and Nutrition, The Hebrew University, Rehovot, Israel*
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¹Department of Oral Biology, The Goldschleger School of Dental Medicine, Faculty of Medical and Health Sciences, Tel Aviv University, Tel Aviv, Israel
²The Center for Nanoscience and Nanotechnology, Tel Aviv University, Tel Aviv, Israel
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¹*Department of Chemistry, The Hebrew University of Jerusalem, Jerusalem, Israel*

², *Carmel Olefins Ltd., Haifa, Israel*

³*Laboratory for Pest Management Research, Institute of Agricultural Engineering, ARO – The Volcani Center, Rishon LeZion, Israel*



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P -01

A GREEN FORMULATION FOR SUPERHYDROPHOBIC COATINGS BASED ON PICKERING EMULSION TEMPLATING FOR ANTI-BIOFILM APPLICATIONS

Raz Cohen, Karthik Ananth Mani, Madina Pirmatova, Gila Jacobi,
Einat Zelinger, Ehud Banin, Elazar Falik, Guy Mechrez *
Volcani Institute, Rishon LeZion, Israel

This study reports significant steps toward developing anti-biofilm surfaces based on superhydrophobic properties that meet the complex demands of today`s food and medical regulations. It presents inverse Pickering emulsions of water in dimethyl carbonate (DMC) stabilized by hydrophobic silica (R202) as a possible food-grade coating formulation and describes its significant passive anti-biofilm properties. The final coatings are formed by applying the emulsions on the target surface, followed by evaporation to form a rough layer. Analysis shows that the final coatings exhibited a Contact Angle (CA) of up to 155° and a Roll-off Angle (RA) lower than 1° on the polypropylene (PP) surface, along with a relatively high light transition. Dissolving polycaprolactone (PCL) into the continuous phase enhanced the average CA and coating uniformity but hindered the anti-biofilm activity and light transmission. Scanning electron microscopy (SEM) and atomic force microscopy (AFM) showed a uniform coating by a "Swiss-cheese" like structure with high nanoscale and microscale roughness. Biofilm experiments confirm the coating`s anti-biofilm abilities that led to the reduction in survival rates of *S.aureus* and *E.coli*, by 90–95% respectively, compared to uncoated PP surfaces.



P -02

UNIFORMIZATION OF BOVINE MAMMARY CELLS USING A STRETCHING DEVICE AIDED BY IMAGE ANALYSIS

Guy Dabby^{1,2}, Nir Zaharoni^{1,2}, Enav Bar-Shira¹, Yifat Brill-Karniely¹

¹Institute of Animal Science., The Volcani Center, Bet-Dagan, Israel

*²The Robert H. Smith Faculty of Agricultural, Food & Environment,
The Hebrew University of Jerusalem, Jerusalem, Israel*

Mechanical forces and the mechano-environment can have major effect on the function of cells. For example, the expression of milk components and other biopolymers by mammary epithelial cells was found to be governed by the mechanical properties of the surrounding. Periodic stretching experiments of cells are a raising theme for studying mechanical effects on monolayers of cells in vitro. However, uniformity in cell size and shape is crucial for the reliability of such experiments. In the ongoing work presented here we develop a method for increasing the morphological uniformity of bovine mammary epithelial cells on silicon chambers that are designated for stretching experiments. For that aim we use the "Cytostretcher" instrument, as well as python codes for image and data analysis. After exploration, we found a specific stretching cycle protocol which largely raises the roundness of the cells and their uniformity. The poster will cover the experimental and analysis tools that we develop as well as the challenges encountered and how we addressed them during the research.



P -03

A DYNAMIC BIOMIMETIC 3D SYNTHETIC SYSTEM AS AN INNOVATIVE AND SUSTAINABLE PLATFORM FOR PEST CONTROL

Michal Amrani^{1,2}, Maya Kleiman¹, Ido Braslavsky³

¹*Plant Science, Volcani Institute, Rishon Le-Zion, Israel*

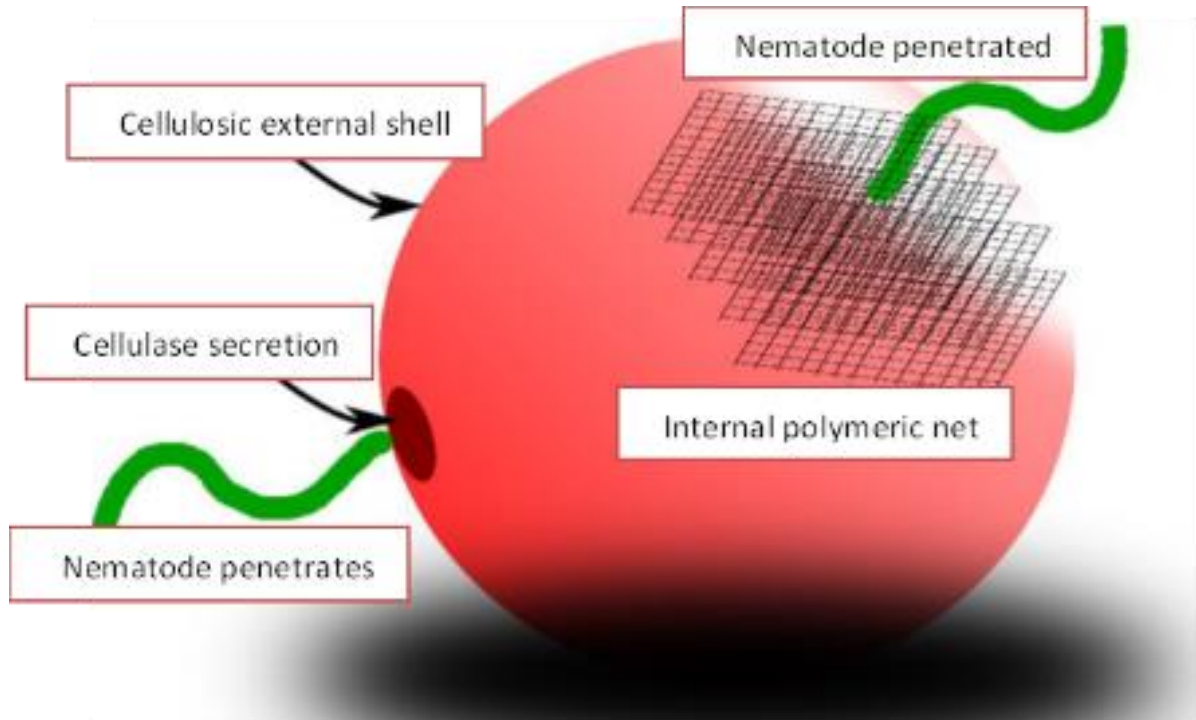
²*Agriculture Faculty, The Institute of Biochemistry, Food Science and Nutrition, The Hebrew University, Rehovot, Israel*

³*Agriculture Faculty, The Institute of Biochemistry, Food Science and Nutrition, The Hebrew University, Rehovot, Israel*

Pesticides are an essential part in the agriculture industry. However, the pesticides used in agriculture are usually toxic and cause environmental damage. My research goal is to bridge the challenge of producing pesticides that are both effective and safe. I propose an innovative type of "pesticide-free" pesticides - in which the mechanism of action is physically trapping the pests rather than chemically killing them. This can be done by construction of a system that includes a biomimetic surface, composed of a natural polymers (cell wall polysaccharides: celluloses, pectins, and hemicelluloses), which will be used as the shell of a capsule containing a physical trap (a net or a maze, also made from natural, biodegradable polymers) that would trap soil pests.

The model pest in my research is the root knot nematodes (RKN). Specifically, the species: *Meloidogyne javanica*. This nematode penetrates the roots of various plants by secreting cell wall degrading enzymes. This obligated pest is considered one of the main pests of many crops around the world.

In my research, I am studying the three main stages of this system: attraction of the nematode to the capsule (by incorporating different natural attractants into the capsule shell material), its penetration inside the capsule and its confinement within the inner network/trap. I am investigating different polymers and compounds and studying how these materials combinations meet these three major aims.





P -04

DNA DELIVERY TO INTACT PLANT CELLS BY CASEIN NANOPARTICLES

Avital Ben-Haim^{1,2}

Department of Food Quality & Safety Institute for Postharvest and Food Sciences, Agricultural Research Organization Volcani Center, Rishon LeZion, Israel

Department of Biochemistry, The Hebrew University of Jerusalem, Rehovot, Israel

This research presents for the first time delivery of DNA into intact plant cells by protein nanoparticles. The studied nanocarriers were casein nanoparticles (CNPs). A plasmid harboring the red fluorescent protein DsRed sequence was absorbed to the surface of the CNPs by electrostatic interaction and has served as a model DNA in this study. The zeta potential of the CNPs is tuned by altering the pH to achieve successful DNA delivery into the cells of the model plant *Nicotiana benthamiana*. The CNPs are covalently modified with the green fluorescent dye 6-Aminofluorescein (6-AF) to determine their location in the plant. To assess the ability of the CNPs to deliver DNA into *N. benthamiana* cells CNPs/DsRed plasmid electrostatic conjugates are infiltrated into *N. benthamiana* leaves. Confocal fluorescent microscopy results showed successful intracellular and nucleus uptake of the CNPs/6-AF/DsRed plasmid conjugates at pH 4.5 (+13.0 mV, 214 nm) and a concentration of 2 mg/ml at CNP: DsRed plasmid ratio of 1:0.01. The expression of the DsRed plasmid was monitored by the fluorescence of the DsRed protein. The first appearance of the emitted red signal of the DsRed protein was observed 24 hrs. post infiltration and remained for 48 hrs.



P -05

PROTEIN-BASED RESINS FOR STEREOLITHOGRAPHY 3D PRINTING

Ayelet Bunin¹, Shlomo Magdassi¹

*Department of Chemistry, The Hebrew University of Jerusalem,
Jerusalem, Israel*

Vat polymerization is a popular 3D printing technique known for its ability to produce complex and precise structures consistently. However, it is difficult to create appropriate photocurable ink formulations for this method, particularly for biocompatible water-based materials, because of the limited availability of suitable materials. Although natural polymers like gelatin are biocompatible, they typically need acrylate modification to be integrated into the polymerization process, which raises concerns about material toxicity.

A new method uses unmodified protein components to create photocurable resin compositions, with a ruthenium-based complex as a photopolymerization initiator. This approach avoids acrylate modification issues and allows for customizable mechanical properties without sacrificing high-resolution printing abilities.

We have achieved a major breakthrough in 3D printing by using resin made of only proteins. This innovation allows for the use of biocompatible materials in 3D printing, which could greatly impact various fields, particularly healthcare using bio-scaffolds. Our research is just the beginning of a larger journey towards more advancements in 3D printing technology and materials science. This breakthrough has significant implications for future research and applications, including bioprinting and beyond.



P -06

CONDUCTIVE PEPTIDE-BASED MXENE HYDROGEL AS A PIEZORESISTIVE SENSOR

Dana Cohen-Gerassi^{1,2,3}, Or Messer³, Gal Finkelstein-Zuta^{2,3}, Moran Aviv^{1,2,4}, Bar Favelukis³, Yosi Shacham-Diamand³, Maxim Sokol³, Lihi Adler-Abramovich^{1,2}

¹*Department of Oral Biology, The Goldschleger School of Dental Medicine, Faculty of Medical and Health Sciences, Tel Aviv University, Tel Aviv, Israel*

²*The Center for Nanoscience and Nanotechnology, Tel Aviv University, Tel Aviv, Israel*

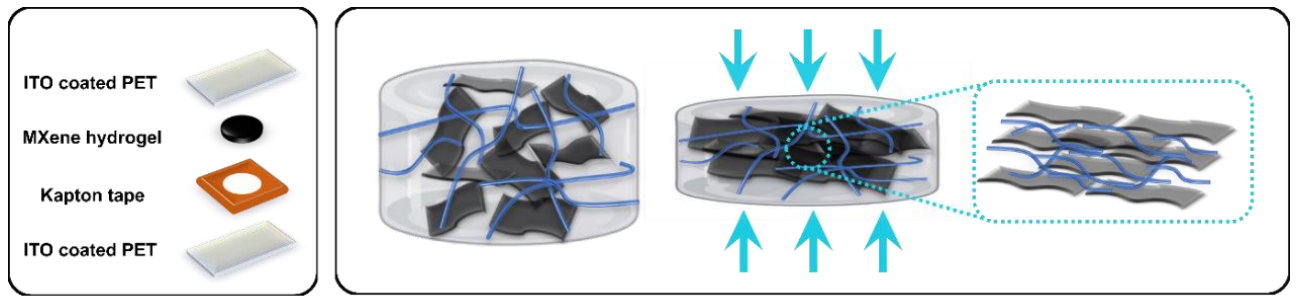
³*Department of Materials Science and Engineering, Tel Aviv University, Tel Aviv, Israel*

⁴*School of Mechanical Engineering, Afeka Tel Aviv Academic College of Engineering, Tel Aviv, Israel*

Wearable pressure sensors have become increasingly popular for personal healthcare and motion detection applications due to recent advances in materials science and functional nanomaterials.

In this study, a novel composite hydrogel is presented as a sensitive piezoresistive sensor that can be utilized for various biomedical applications, such as wearable skin patches and integrated artificial skin that can measure pulse and blood pressure, as well as monitor sound as a self-powered microphone.

The hydrogel is composed of self-assembled short peptides containing aromatic, positively- or negatively charged amino acids combined with 2D Ti₃C₂T_z MXene nanosheets. This material is low-cost, facile, reliable, and scalable for large areas while maintaining high sensitivity, a wide detection range, durability, oxidation stability, and biocompatibility. The bioinspired nanostructure, strong mechanical stability, and ease of functionalization make the assembled peptide-based composite MXene-hydrogel a promising and widely applicable material for use in bio-related wearable electronics.



Cohen-Gerassi, D., Messer, O., Finkelstein-Zuta, G., Aviv, M., Favelukis, B., Shacham-Diamand, Y., Sokol, M., & Adler-Abramovich, L. (2024). Conductive Peptide-Based MXene Hydrogel as a Piezoresistive Sensor. *Advanced Healthcare Materials*. <https://doi.org/10.1002/adhm.202303632>



P -07

RESILIENT INJECTABLE NATURAL POLYMER-BASED SCAFFOLDS FOR BREAST TISSUE REGENERATION

Daniella Goder Orbach¹, Geffen Coster², Ilana Roitman², Or Hadad², Meital Zilberman¹

¹Department of Biomedical Engineering, Tel Aviv University, Tel Aviv, Israel

²Department of Materials Science and Engineering, Tel Aviv University, Tel Aviv, Israel

Scaffolds for tissue regeneration are implants that support and promote cell ingrowth and therefore new tissue formation. These implants must fit the defect area precisely and match the mechanical properties of the surrounding tissue. Soft tissue continuously undergoes cyclic loading, for example during walking, breathing etc., and withstanding these forces together with having mechanical properties that fit very soft tissues, such as adipose tissue, has been a challenge. We have developed an injectable and in-situ crosslinking porous scaffold for adipose tissue regeneration following a partial breast mastectomy. The scaffold is designed to enable cell adhesion and infiltration to create new tissue while it degrades, leaving only the de-novo tissue in place. Furthermore, the use of the natural polymers gelatin and alginate, makes this scaffold highly biocompatible.

Various scaffold formulations were prepared and tested for mechanical, physical and biological properties. Young's modulus in compression and tension fit the requirements for very soft tissue applications. Resilience was tested as well and was extremely high for all formulations. Cytotoxicity tests indicated no toxic effect on fibroblasts and preadipocytes. Results of the various formulations show that small changes to the scaffold allow versatility in use and ability to fit several different soft tissues.

The scaffolds discussed here enable tissue regeneration using biocompatible and biodegradable natural polymers. Injectability makes this a minimally invasive procedure, and in-situ crosslinking allows the scaffold to fit the defect perfectly. The combination of these is expected to reduce hospitalization costs and improve patient quality of life as a part of breast cancer treatment.



P -08

LIVING MICRONEEDLES FOR THE TREATMENT OF SKIN INFECTIONS

Caroline Hali¹, Noa Ben David¹, Boaz Mizrahi¹

*Department of Biotechnology and Food Engineering, Technion -
Israel Institute of Technology, Haifa, Israel*

Living biomaterials are the result of a combination of live organisms such as bacteria or cells with traditional biomaterials. This integration yields a unique system that enjoys the best of both worlds: a live manufacturer that can sense its environment, produce, and release biomolecules while exhibiting excellent stability in harsh physiological milieus. In this research we hypothesized that a live bacterial formulation could continuously release and deliver therapeutic agents with the potential to be an alternative to traditional treatments against bacterial skin infections. Our structure motif is based on incorporating *Bacillus subtilis*, gram-positive bacteria that produce and secrete antimicrobial and anti-inflammatory molecules into a dermal microneedles (MNs) arrays. MNs were successfully fabricated using an in-house micromolding technique. The mechanical forces of these MNs were assessed using a tensiometer and found to be clinically satisfactory. Insertion of MNs into mice skin ex-vivo demonstrated the presence of *B. subtilis* in the dermis layer, in agreement with the prediction based on needle height of 500 μm . Bacteria were recovered from the MNs within 4 h, followed by a stationary phase after 12 h. Bacterial loaded MNs showed significant inhibitory growth of *Staphylococcus aureus*, *Streptococcus pyogenes* and *Cutibacterium acnes* in vitro. This inhibition was more pronounced than those of free *B. subtilis*. Thus, this versatile MN array is potentially valuable for treating skin infections in clinical applications.



P -09

THE EFFECT OF SURFACE MICROSTRUCTURES AND MICRO-CLIMATE OF BIOLOGICAL AND SYNTHETIC SURFACES ON MICROORGANISMS AND THEIR INTERACTIONS USING BIOMIMETICS AND THERMAL IMAGING.

Nofar Hod^{1,2}, Maya Kleiman¹, Iris Yedidia¹, Yafit Cohen³, Manoj Pun^{1,2}, Tali Sayas¹

¹Plant science, Volcani Institute, Rishon Le-Zion, Israel

²Agriculture Faculty, The Hebrew University, Rehovot, Israel

³Agriculture Engineering, Volcani Institute, Rishon Le-Zion, Israel

Surface architecture and its effect on bacterial attachment, colonization and micro-environment, are poorly understood. Our aim is to unravel the complex interaction of leaf surfaces with bacterial cells, and explore the mechanism by which microstructures and micro-climate influence bacterial behavior and gene regulation. For that purpose, two closely related ornamental species of the genus *Zantedeschia*, were chosen as model hosts for the soft rot pathogen *Pectobacterium brasiliense*. While *Z. aethiopica* (ZA) has a relatively smooth, less competent surface for bacterial cell attachment, the hybrid cultivar `Captain Romance` (CR) has a rough surface, which is highly compatible for bacterial colonization (Guttman et al., 2021). Using thermal imaging (changes are manifested through the drying process of droplets, influencing surface temperature) and biomimetic replicas of leaf surfaces, we will be able to associate between the phytopathogen attachment patterns, the surface microstructure and the micro-climate, and to examine if there is a direct linkage between bacterial behavior and the microstructure in correlation with the micro-climate.

Finally, colonization patterns will be manipulated by the use of plant secondary metabolites and other nanoparticles that will be externally applied or incorporated to the surfaces in order to reduce or block microbial attachment.

The proposed system aims to offer crucial information about the development potential of microorganisms on surfaces. Additionally, the system will enable manipulation by altering microclimate or surface microstructure and hydrophobicity.

Reference

Guttman, Yelena, et al. "Ecological adaptations influence the susceptibility of plants in the genus *Zantedeschia* to soft rot *Pectobacterium* spp." *Horticulture Research* 8 (2021).



P -10

4D-PRINTED PH SENSITIVE HYDROGELS

Timna Korem, Salome Azoulay-Ginsburg, Roey Amir

Hydrogels are 3D structures assembled from either covalently crosslinked or physically held networks of polymer chains, capable of holding a large amount of water. Smart 3D-printed hydrogels can react to environmental stimuli by changing their structure/shape and are referred to as 4D printed materials. In response to stimuli, the polymer chains can get further away one from the other, causing the swelling of the hydrogel. The swelling of the hydrogel, can on one hand, lead the hydrogel to absorb more water from the surrounding, and on the other hand, allow substances to be released from the hydrogel to the surrounding by diffusion. This research focused on pH sensitive hydrogels as potential drug delivery systems.

One of our goals was to better understand the swelling and release mechanisms of 3D printed pH sensitive hydrogels. To achieve this, we used acrylic acid (AA) as a monomer to 3D print polyacrylic acid (PAA), which when reacting with a base becomes negatively charged. The repulsion between these negative charges causes the PAA chains to move away from each other, resulting in observed swelling of the hydrogel. In addition, hydrogels printed from solutions containing only responsive monomers swelled significantly more than hydrogels, which contained a mixture of responsive and non-responsive monomers. When placed in acidic solutions the hydrogels shrunk due to protonation of the carboxylate side-groups, decreasing both the repulsion between the chains and their hydrophilicity.

We next used 4-nitrophenol as a model for drug encapsulation and release. Surprisingly, our findings contradicted our initial expectation that loaded substance would diffuse out faster upon swelling. The hydrogels which were placed in acidic solution released approximately double the amount of the loaded substance compared to those in basic solution. Therefore, we hypothesize that during the shrinkage, the hydrogels forced out the loaded cargo molecules.

The final goal of this research was to print hydrogels containing layers from two different solutions; one contains responsive monomers and the second non-responsive monomers, and to study the effect of pH changes on these hydrogels. As the DLP printer isn't designed for printing from more than one solution, we developed a new method of printing and tested different options for replacing the resin in the printer's vat. We found that the order in which the solutions are applied had great significance. Specifically, only when the non-responsive monomer solution was used first was the



printing successful, resulting in fully printed models. When placed in a basic solution, the bilayer hydrogels folded due to the different degree of swelling between the responsive PAA based layer and the non-responsive layer.

Overall, this project improved our understanding of the properties of pH responsive hydrogels and the parameters that can be tuned to control their response. The obtained results and knowledge will help to design responsive hydrogels for specific applications such as sustained drug delivery system.



P -11

HYBRID POLYMERS WITH ENHANCED ANTIBACTERIAL AND WOUND HEALING CAPABILITIES

Dana Mizrahi¹, Shay Weiss², Amir Ben-Shmuel², Victoria Nahum¹

¹*Organic Chemistry, IIBR, Ness Ziona, Israel*

²*Infectious Diseases, IIBR, Ness Ziona, Israel*

Novel hybrid polymers were designed and synthesized, employing two separate biocides and an inactive linker. The compounds exhibited strong broad-range antibacterial efficiency and synergistic action. The hybrid materials are designed to refrain from inducing bacterial resistance. Following initial testing, these compounds were formulated into a topical gel, and several wound dressings, such as gauze, PVP film and PVP fleece. The formulations were tested *in vitro* against 6 strains of bacteria and spores, including resistant bacteria, and two strains of fungus. Their action was also compared to commercial PVP-iodine (Polydine) gel, and was found to be superior. *In vivo* tests in mice with bacteria-contaminated wounds showed that the topical gel and PVP fleece afforded enhanced wound healing.



P -12

STABILIZATION OF DOPA-PHE(4F)-PHE(4F)-OME WITH TPU VIA ELECTROSPINNING FOR BIOMEDICAL APPLICATIONS

ABINAYA NALLATHAMBI^{1,2}, Enrica Chiesa¹, Mariella Rosalia¹,
Ida Genta¹, Meital Rechtes²

¹*Department of Drug Sciences, University of Pavia, Pavia, Italy*

²*The Hebrew University of Jerusalem, Institute of Chemistry and The Center for Nanoscience and Nanotechnology, Jerusalem, Israel*

The field of medical implants and prosthetics faces challenges due to infections and immune rejection, necessitating materials that prevent bacterial adhesion and promote tissue regeneration.

This study presents the electrospinning of the peptide DOPA-Phe(4F)-Phe(4F)-Ome into nanofibrous scaffolds. Despite its robustness, solubility tests in pH-controlled environments revealed instability of the fibres prompting further investigation. To enhance stability, the peptide was blended with thermoplastic polyurethane (TPU). Scanning electron microscopy exhibited a distinctive dual-range morphology of the fibres in the composite, indicating effective blending. X-ray photoelectron spectroscopy (XPS) confirmed peptide distribution, marked by fluorine presence. The composite was further investigated to demonstrate its release capacity and influence on the breakdown of the polymer using high pressure liquid chromatography (HPLC) and short-term degradation studies. Our findings suggest the successful integration of DOPA-Phe(4F)-Phe(4F)-Ome with TPU, overcoming stability issues and demonstrating its potential for biomedical applications. The resulting composite material offers improved stability and functionality, representing a promising advancement in biomaterials for medical implants and prosthetics.

Keywords: DOPA-Phe(4F)-Phe(4F)-Ome, electrospinning, thermoplastic polyurethane (TPU), scanning electron microscopy (SEM), stabilization.



P -13

**PICKERING EMULSIONS STABILIZED BY SOY PROTEIN
NANOPARTICLES FOR TARGETED DELIVERY OF NUTRIENTS FOR
CULTURED MEAT**

Madina Pirmatova

The Volcani Institute, Rishon Le Zion, Israel

The current world population is 8 billion as of July 2023, according to the estimation elaborated by Worldometer. The value is expected to reach 9 billion in 2037. Given these facts, humanity will face severe food insecurity associated with increasing hunger in the coming decades. Along with population growth, there is a need to expand agricultural land and animal husbandry. But enlarged industrialization of livestock is a double-edged sword due to accompaniment by ecological issues. The polluting components of livestock is discharged into natural waters, which can cause massive fish extermination and significantly disrupt the chemical and biological balance of the reservoirs. The greenhouse effect causes a significant increase in the planet's temperature. To meet the ongoing problems, an animal husbandry alternative is needed. Cultured meat aims to resolve issues related to industrial farming by circumventing some of its undesirable consequences. Cell-based meat muscle fibers and adipose tissue form and mature using a specific differentiation factor (DFs). To maximize the effectiveness of the last and its biologically relevant applicability, Pickering emulsion encapsulation systems developed to enhance cellular proliferation and differentiation by controlling how much, when, and where GFs should be released. Pickering emulsions are based on a self-assembly of colloidal particles at the interface between two non-miscible liquids. Usually, the colloid stabilizers have a preference for a particular phase based on the particles' wettability features which allows emulsion type prediction. That delivery system will protect low stability and rapid inactivation of DFs by enzymes under invitro cell growing conditions.



P -14

SPIDER-SILK-ENRICHED ALGINATE FOR CELL BIOPRINTING

Tali Tavor Re'em¹, Ella Sklan²

*¹Pharmaceutical Engineering, Azrieli College of Engineering,
Jerusalem, Israel*

²Biological Applications, Seevix, Jerusalem, Israel

Recombinant spider silk-inspired biopolymer (SVX), produced by E.Coli, offers unique properties for cell bioprinting: porosity, exceptional strength, elasticity, and biocompatibility. Growth factors (GFs) are essential for cell growth; however, their high cost poses a significant challenge. GFs are used in various applications, but in this research, they were employed with bMSC (bovine mesenchymal stem cells) as part of Seevix's participation in the Israeli Cultured Meat Consortium. The effectiveness and quantities of GFs are of crucial significance for the cultivated meat industry due to cost considerations.

Recombinant spider silk-inspired biopolymer (SVX) was produced by Seevix Material Sciences. SVX-alginate bioink was bioprinted using an Allevi 2 bioprinter, demonstrating a higher degree of printability, in terms of lower spreading ratio at lower pressures, compared to alginate. Bioprinting of bMSCs within the SVX-enriched alginate bioink resulted in a prolonged and higher cell viability, evaluated by CellTiter Glo 3D kit, compared to alginate (p0.05).

The absorption capacity of 3D-printed alginate hydrogels enriched with SVX was evaluated using Casein and examined by a spectroscopic analysis. Higher absorption rates were shown for Casein in the SVX-enriched alginate models. Under serum starvation, bMSC bioprinted alginate hydrogels treated with FGF2 demonstrated higher cell viability in SVX-incorporated cultures compared to alginate (p0.05).

To conclude, the incorporation of SVX spider silk biopolymer into scaffolds contributed to higher viability of cells, presumably by increased porosity and increased mass transfer enhancing the accessibility of GFs to bioprinted hydrogels. This study opens new avenues for developing cost-effective and efficient cell-based applications.



P -15

HIERARCHICAL POROSITY IN EMULSION-TEMPLATED BLOCK COPOLYMER MONOLITHS: PHASE SEPARATION, DEGRADATION, AND HYPERCROSSLINKING

Shani Admoni^{1,2}, Orit Cohen², Krzysztof Matyjaszewski³, Michael Silverstein²

¹*Interdisciplinary Program in Polymer Engineering, Technion - Israel Institute of Technology, Haifa, Israel*

²*Department of Materials Science and Engineering, Technion - Israel Institute of Technology, Haifa, Israel*

³*Department of Chemistry, Carnegie Mellon University, Pittsburgh, PA, USA*

Hierarchical porosities are often used to enhance application efficiencies. This research is focused on designing hierarchically porous polymer monoliths where macropores (50 nm) were generated via emulsion templating, mesopores (2 - 50 nm) were generated via block copolymer templating, and micropores (2 nm) were generated via hypercrosslinking. To this end, atom transfer radical polymerization (ATRP) was used to synthesize triblock copolymers (TBCs) from a degradable polycaprolactone (PCL) macroinitiator (MI).

In one approach, a crosslinkable TBC based on glycidyl methacrylate (GMA) was synthesized and the resulting TBC was then crosslinked within the external phase of an oil-in-oil medium internal phase emulsion (30-74% internal phase) using tris(2-aminoethyl)amine. The resulting monolith had a density of 0.127 g/cm³, and an average void diameter of 14 μm. Degradation in 0.1 M NaOH produced a significant increase in the mesopore volume (from 0.0095 to 0.0180 cm³/(g·nm)) and a slight increase in the average mesopore width (from 10.4 to 11.1 nm). The generation of micropores through swelling and then crosslinking the remaining epoxides is being investigated. In a second approach, a monolith with interconnected porous channels and a density of 0.159 g/cm³ was synthesized through the ATRP of styrene (S) and divinylbenzene (DVB) from the PCL-MI within a water-in-oil high internal phase emulsion (74% internal phase). Hypercrosslinking by Friedel-Crafts alkylation produced a specific surface area of 798 m²/g, mesopores with average width of 3.5 nm, and micropores with average width of 0.7 nm. The design and control of the mesoporous structure by enhancing phase-separation within the BCP and by enhancing the removal of the degradable block is being investigated.



P -16

**PICKERING EMULSIONS STABILIZED BY MAGNETIC
NANOPARTICLES FOR BIOSEPARATION AND DETECTION OF FOOD
AND WATER PATHOGENS**

Reut Amar Feldbaum¹, Guy Mechrez¹

*Department of Food Science, Agricultural Research Organization -
Volcani Institute, Rishon LeZion, Israel*

Magnetic nanoparticles, such as Fe_3O_4 , have a great potential to function as a rapid and facile platform for bioseparation and detection of food pathogens due to their high surface area that is resulted from their nanoscale and the ability to selectively collect them from contaminated samples by a commercial magnet. However, until now, the ability to develop a robust technology for the bioseparation and detection of food pathogens based on MNPs is limited due to their nanoscale. Although their nanoscale enables high collection efficacy, it also leads to a very low magnetic field once exposed to an external magnet. Only a significant increase in the MNPs diameter or their agglomeration would sufficiently increase the obtained magnetic field and allow their proper collection by an external magnet. However, it would dramatically decrease their active surface area and eliminate their ability to function as efficient collectors for microorganisms at high efficacy. In this proposal, we will develop magnetic Pickering emulsions that would allow faster and easier bio-separation at high efficiency. The assembly of MNPs with a large surface area on the surface of an oil droplet in a monolayer serves, in this case, as a unique solution that allows to maximize of the magnetic field to that of agglomerates and, simultaneously maintaining their high surface area.

A. Successful magnetization and separation process of the emulsion once added to a contaminated aqueous sample. B. The emulsion magnetization process due to external magnet at different time points.



P -17

MATERIALIZING THE FUTURE

Jonathan Antebi¹

Department of Marketing, Nemo Nanomaterials, Petah Tikva, Israel

Nemo Nano materials develops and manufactures well dispersed concentrates based on Single Walled Carbon Nano Tubes. Nemo's materials are ready-to use solution on existing industrial equipment enabling new set of properties like lightweight Carbon-based EMI shielding in plastics, electrical conductivity and more.

The high efficiency of the masterbatches is achieved through a combination of unique formulation and processing technology, enabling outstanding dispersion within the ultimate application.

NemoBlend™ masterbatch is designed to achieve controlled electrical conductivity in different thermoplastic polymers for extrusion or injection molding applications. Subject to the designed process and dosing rate, the NemoBlend™ masterbatches may provide wide range of volume resistivity.

NemoBlend™ masterbatches also offer easy processability, long runs with no die buildup, and can be mixed with dark color masterbatches to obtain colored products.



P -18

SOFT SUPERHYDROPHOBIC STRUCTURES BY DIGITAL LIGHT 3D PRINTING

Noa Battat¹

*Institute of Chemistry, The Hebrew University of Jerusalem,
Jerusalem, Israel*

The field of additive manufacturing, commonly referred to as 3D printing, has seen significant growth in recent years and showcases a diverse array of promising applications, among it the field of soft materials.

We aim at developing materials and approaches to fabricate 3D objects with capability of self-cleaning. An associated concept with self-cleaning is superhydrophobicity, which describes extreme water-repellency, a property that can create self-cleaning ability, resistance to bacteria adhesion, protection against corrosion, and prevention of icing. This characteristic takes inspiration from the phenomenon known as the `Lotus effect`, observed in lotus leaves. Through the combination of superhydrophobicity and surface texturing facilitated by 3D printing, an effect biomimicking the Lotus effect can be achieved. Furthermore, the introduction of hydrophobic nanoparticles into the micro-structures imparts a digitally controllable roughness to the surface, enabling for the acquirement of superhydrophobicity via digital manipulation.

Our research aims at the development of superhydrophobic structures using a digital light 3D printing process, to be mainly used in soft robotics scope. The structures will possess self-cleaning attributes, opening up potential applications across diverse domains such as medicine, agriculture and soft robotics.



P -19

DIGITAL LIGHT PROCESSING 3D PRINTING OF STRETCHABLE AND COMPRESSIBLE POROUS POLYMERS FOR SOFT ROBOTICS

Ouriel Bliah¹, Seonggun Joe², Roei Reinberg¹, Luccia Beccai²,
Shlomo Magdassi¹

¹*Department of Chemistry, The Hebrew University of Jerusalem,
Jerusalem, Israel*

²*Soft Biorobotics Perception Lab, Istituto Italiano di Tecnologia,
Genova, Italy*

This research presents a novel, highly stretchable, and compressible porous materials using 3D-printing technology. Utilizing a photopolymerizable water-in-oil (W/O) emulsion, where water droplets act as pore templates and a flexible polyurethane diacrylate serves as the continuous phase. The porosity is made possible by converting the polymerizable emulsions into open-cell structures upon printing and removing internal water droplets. The resulting material structures exhibit the highest reported elongation-at-break of 450% for 3D-printed porous structures and excellent reversible compressibility at 80%, providing both compliance and strength to the material. Furthermore, the presented approach allows for fabricating high-resolution complex objects with tailored porosity, incorporating both macro-pores by design and micro-pores by the material's inherent properties. We show the potential application in the field of soft robotics by fabricating novel grippers with unique actuation performance, shape adaptability, and high holding force. This approach of employing polymerizable emulsions in 3D printing has far-reaching implications across multiple application domains, including personal safety gear, healthcare, and defense technologies. The technique holds significant promise for advancing the field of polymer science, particularly in those used for additive manufacturing.



P -20

RHEOLOGICAL BEHAVIOR OF BRANCHED SUPRAMOLECULAR POLYMERS

Carmel Cohen¹, Ishay Columbus¹, Nawal Fahoum¹, Maya Davidovich-Pinhas², Roy Shenhar¹

¹*Institute of Chemistry and the Center for Nanoscience and Nanotechnology, The Hebrew University of Jerusalem, Jerusalem, Israel*

²*Faculty of Biotechnology & Food Engineering and the Russell Berrie Nanotechnology Institute, Technion, Israel Institute of Technology, Haifa, Israel*

Supramolecular polymers represent a unique family of polymers, in which the repeat units are connected by non-covalent interactions such as hydrogen bonds. This virtue makes them specifically intriguing, because under certain conditions they could disassemble into individual molecules and give rise to low viscosity solutions, whereas under different conditions they behave like conventional polymeric chains that tend to entangle, resulting in elastic materials. Environmentally responsiveness and self-healing are thus part of their identity.

We recently introduced branching – a fundamental aspect in polymer science – into supramolecular polymers, and showed its dramatic influence on the solution viscosity.[1] In this work, we studied the rheological behavior of branched supramolecular polymers and compared it to the known behavior of linear supramolecular polymers.[2] Interestingly, we found that branching leads to an unusual frequency-dependent response of the storage and loss moduli, which raises the possibility for a complex relaxation mechanism that is unique to branched supramolecular systems.

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P -21

ADDITIVE MANUFACTURING OF POLYPOSS/KAPTON TWO-WAY SHAPE MEMORY POLYMER ACTUATORS

Nicole Gorohovsky¹

*Department of Materials Science and Engineering, Tel Aviv
University, Tel Aviv, Israel*

Two-way shape memory polymers (2WSMPs) are a fascinating class of materials with the unique ability to exhibit two distinct shapes and transition between them in response to external stimuli. Upon exposure to a specific stimulus, such as heat or humidity, the polymer undergoes a reversible transition, enabling it to switch back and forth between the two shapes. This dynamic behaviour of 2WSMPs opens up a wide range of potential applications in fields like medicine, aerospace, robotics, and textile.

In this project, a 2WSMP actuator was manufactured for the first time via a 3D printing technique of PolyPolyhedral Oligomeric Silsesquioxanes (PolyPOSS) thermoset on Kapton film.

Physical parameters such as PolyPOSS gelation time at various temperatures, as well as PolyPOSS wetting on Kapton substrates were investigated.

Poly POSS's printing parameters were investigated, and ideal parameters were identified. Parameters such as printing speed, volumetric rate, layer height, and layer width were investigated. A set of printing parameters which yield the lowest printing index, i.e., the most unified printing lines, was chosen.

The optimal line distance was then tested. Finally, a 2WSP actuator was printed. The actuators' response to various temperatures was compared to a finite element simulation.

We thus showed that using additive manufacturing allows creating complex structures which would be nearly impossible with conventional casting manufacturing methods.



P -22

FABRICATION OF ANTIMICROBIAL POLYMERIC FILMS BY COMPRESSION MOLDING OF PEPTIDE ASSEMBLIES AND POLYETHYLENE

Michaela Kaganovich¹, Koranit Shlosman², Evgeniya Goldman²,
Marina Benchis³, Tamar Eitan³, Rotem Shemesh², Abraham
Gamliel³, Meital Rechtes¹

¹*Department of Chemistry, The Hebrew University of Jerusalem,
Jerusalem, Israel*

²* , Carmel Olefins Ltd., Haifa, Israel*

³*Laboratory for Pest Management Research, Institute of Agricultural
Engineering, ARO – The Volcani Center, Rishon LeZion, Israel*

Reducing microbial infections on polymer surfaces is a serious problem in many areas, including agriculture, medicine, and food. We produced novel antimicrobial films by compression molding of peptide assemblies with low-density polyethylene (LDPE). The peptide self-assembles in an aqueous medium into spherical structures with antimicrobial properties. After lyophilization, used to yield a fine powder, these particles were melt-compounded with LDPE, followed by compression molding to produce 100 μm thick polymeric films. Importantly, these films showed a significant reduction of viruses and bacteria by 80%. Moreover, they significantly inhibited the growth of the fungi *Pythium* sp., *Fusarium oxysporum*, and *Sclerotium rolfsii*. These innovative active polymeric films can be applied for medical device wrapping, food packaging, and agriculture applications where crop protection is needed.



P -23

**SOFT SURFACE-ENHANCED RAMAN SCATTERING SENSING
PLATFORM BASED ON OIL-IN-WATER EMULSION STABILIZED BY
SILVER NANOPARTICLES**

Hagai Klein¹, Guy Mechrez¹

*Department of Food Sciences, Agricultural Research Organization
(ARO), Volcani Institute, Rishon Letzion, Israel*

Pickering emulsions have a great potential to be utilized for the development of soft biosensors for the detection of native biomolecules (such as DNA, RNA, peptides, and proteins), notably through surface-enhanced Raman spectroscopy (SERS) transduction mechanism. Herein, the efficiency of Ag nanoparticles (Ag NPs) embedded into mineral oil (RTM2) based Pickering emulsions was evaluated by monitoring a representative Raman active molecule (4-Aminothiophenol, 4ATP). The physiological properties and compositions of the produced Pickering emulsion were thoroughly studied for optimized optical response. The resulting SERS signals outperformed equivalent metal content colloidal dispersions by 10-fold, presenting a linear response toward the target molecule. The superior optical response of Pickering emulsions could potentially pave the way for unlimited wet-based biosensing events while detecting analytes in their native form.



P -24

MODULAR METAL-BIPYRIDINE BASED CONJUGATED AEROGELS AS CATALYSTS FOR OXYGEN REDUCTION REACTION

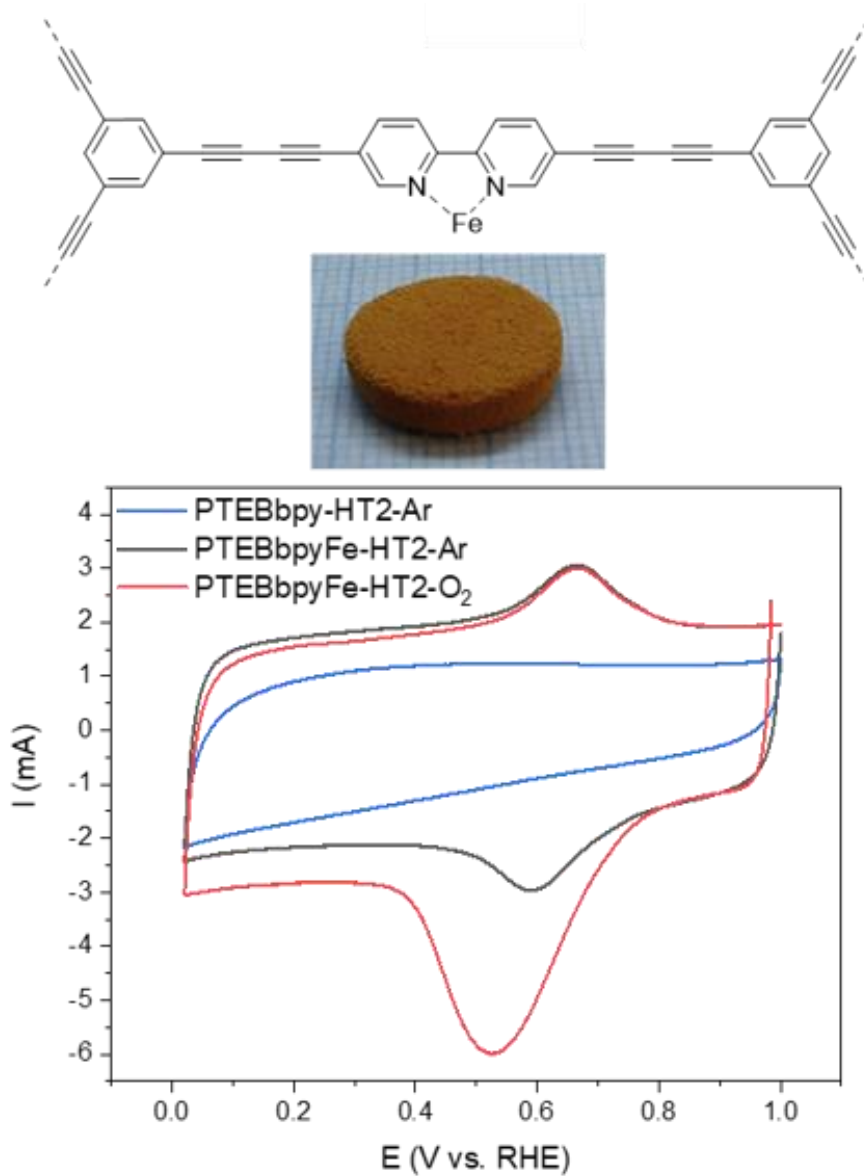
Leigh Peles Strahl^{1,2}, Adi Dahan², Lior Elbaz¹

¹*Department of Chemistry, Bar-Ilan University, Ramat Gan, Israel*

²*Department of Chemistry, Soreq NRC, Yavne, Israel*

Aerogels have large surface area and porous structure which make them attractive catalyst support material for fuel cells. Modifying the aerogels` building blocks and introducing catalytic sites into their backbones allows them to function as both catalysts and supports, thereby increasing the density and distribution of catalyst active sites.

In this work, we present conjugated aerogels containing metal-bipyridine catalytic sites for oxygen reduction reaction (ORR). We demonstrate the variation in physical and electrochemical properties of these aerogels, by changing the bipyridine content and metal percent and species. The 3D organic gels were synthesized by Glaser coupling reaction. After supercritical drying and washes, the aerogels were heat treated to produce ORR active carbon aerogels. The complexation strategy varies depending on the metal (Cu or Fe), which were introduced in different stages of the fabrication: in-situ or post polymerization, for Cu and Fe respectively. The aerogels were thoroughly characterized and the results show a correlation between metal species and loading, aerogel structure, and the catalytic activity, achieving high performance for the ORR in both acidic and alkaline media.



Scheme of the PTEBbpyFe structure, aerogel figure, and CV measurement of PTEBbpyFe-HT2 under Ar and O₂, and PTEBbpy-HT2 under Ar, in acidic conditions.

ACS catalysis, 2023, 13, 21, 14377–14384

Advanced functional materials, 2021, 2100163



P -25

**SPATIAL CONTROL OVER SOLUBILITY AND MECHANICAL
PROPERTIES OF PHOTOPOYLMEMRS IN VAT
PHOTOPOLYMERIZATION.**

Yali Reuveni¹, Liron Ben-Arush¹

*Materials Engineering, Azrieli College of Engineering, Jerusalem,
Israel*

Photopolymerization 3D printing (VPP) is a precise and rapid technology for manufacturing 3D objects from digital models. However, this method is limited to using a single resin, which makes it difficult to print supports and to create objects with spatially varying properties.

This project develops new resin formulations that enable multi-material printing which solves the support problem by using photopolymerizable compounds that change their solubility depending on the irradiated wavelength. A model can be printed from a single material and supports can be easily and cheaply removed by dissolving them in water. And another formulation that allows printing of a material with different mechanical properties in different regions.

Our Project goals are to Develop formulations that allow control of the polymerization mechanism by using different wavelengths of light, followed by performing solubility, mechanical, and thermal tests on printed formulations, as well as Creating a suitable post-process of printed models to obtain a high-quality product.

For the time being several suitable formulations have been identified. Our following steps are to: Find the optimal polymerization time, print models for testing and create a suitable post-process.

The project is expected to lead to a significant breakthrough in the field of 3D printing, opening new possibilities for the production of complex and functional objects.

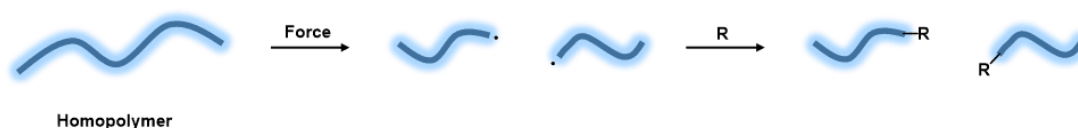


P -26

TELECHELIC POLYMERS FROM MECHANOCHEMICAL C-C BOND ACTIVATION

Rony Schwarz¹, Charles E. Diesendruck

Schulich Faculty of Chemistry, Technion - Israel Institute of Technology, Haifa, Israel



Selective activation of simple C-C bonds is a highly desirable transformation in organic chemistry which can only be achieved with specific substrates using transition metal catalysis.[1] On the other hand, C-C bond scission is the most common outcome in polymer mechanochemistry, where mechanical energy drives chemical reactions in macromolecules. Mechanochemical reactions require a minimal macromolecular length, and typically results in backbone scission and polymer length reduction.[2]

In this work, we describe how unstrained C-C bond activation is attained in homopolymers through mechanochemical homolytic bond scission followed by functionalization to yield telechelic polymers. Ball milling poly(ethylene oxide) (PEO) in the presence of 1-(bromoacetyl)pyrene (BAPy) yields the pyrene terminated PEO. PEOs with a molecular weight below 20 kDa shows no functionalization, supporting a mechanochemical over a thermal mechanism. Similarly, milling with 2,4'-dibromoacetophenone followed by Suzuki coupling allows the introduction of various aryl end groups. The protocol was also tested with doxorubicin, yielding the drug-polymer conjugate. PEO halogenation is also demonstrated by milling PEO with iodine, N-bromosuccinimide or N-iodosuccinimide, which could then be reacted with an amine substituted anthracene. Grinding of additional carbon polymers with BAPy indicates that this functionalization method is general for different polymer chemistries.

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SOFT PRINTING OF GOLD NANOISLANDS ON FLEXIBLE POLYMERIC SUBSTRATES

Aleksei Solomonov¹, Anna Kozell¹, Alexander Tesler², Iddo Pinkas³,
Seth Walensky¹, Ulyana Shimanovich¹

¹*Department of Molecular Chemistry and Materials Science,
Weizmann Institute of Science, Rehovot, Israel*

²*Department of Materials Science and Engineering, Friedrich-
Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany*

³*Department of Chemical Research Support, Weizmann Institute of
Science, Rehovot, Israel*

We designed and developed a facile soft-printing approach to efficiently functionalize flexible polymeric materials with a series of gold nanoparticles and nanoislands (AuNIs) with tunable plasmonic characteristics. The synthetic route is based on Au nanostructures formation (ca. 2–300 nm) on a glass substrate followed by gentle hydrophobization of the functionalized surface, which in turn, allows efficient transfer of AuNIs to flexible adhesive films via soft-printing tape lithography. Owing to precise control of the gold nanostructures size, soft plasmonic films with unique spectral-selective optical properties were produced. We believe that the proposed method will be of interest in the development of advanced flexible polymer-based optical materials.



P -28

HYDROPHOBICITY AS A TOOL FOR PROGRAMMING SEQUENTIAL MESOPHASE TRANSITIONS OF POLYMERIC AMPHIPHILES

Shahar Tevet¹

Organic Chemistry, Tel Aviv University, Tel-Aviv, Israel

In this work, we wished to show the ability to program the mesophase transition rates of co-assembled enzyme-responsive polymeric systems, from micelles to hydrogels, by a fine adjustment of the systems' hydrophobicity. Whereas in our previous study, we focused mainly on the establishment of such a system, here our focus shifted to revealing the amphiphiles' hydrophobicity, an unexplored parameter in this context, as a useful tool that can be used to control these kinetics. To achieve this goal, we have designed three types of PEG-dendron di-block amphiphiles and used their intrinsic high-molecular precision to fine-tune their hydrophobicity, as well as a comparable tri-block amphiphile with a single type of hydrophobicity.

These amphiphiles were used to fabricate and stabilize three co-assembled micellar systems, which were monitored for the amphiphiles' degradation rate and gelation profile under exposure to a model enzyme. Although we modified the DBAs' hydrophobic-dendritic-block by only four methylene units each time, this seemingly neglectable change in the amphiphiles' design had a remarkable effect on the rate of these transitions, from a few hours to one week. Moreover, by increasing the overall hydrophobicity of the TBA in comparison to our previously reported system, we were able to generate a hydrogel that is far more stable towards enzymatic degradation and disassembly.

This study sheds light on how parameters such as molecular architecture and hydrophobicity could have a remarkable ability to program mesophase transitions precisely within enzyme-responsive polymeric assemblies, and should be considered as key factors in the designing of such systems.



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EMULSION TEMPLATING OF RIGID, TWISTED MACROMOLECULES FOR HIERARCHICAL POROSITY

Kristina Vetlitsyna-Novikova¹, Orit Cohen², Michael S. Silverstein²

¹*Interdisciplinary Program in Polymer Engineering, Technion – Israel Institute of Technology, Haifa, Israel*

²*Department of Materials Science and Engineering, Technion – Israel Institute of Technology, Haifa, Israel*

Templating within internal phase emulsions (HIPEs) makes it possible to prepare macroporous polymer monoliths (polyHIPEs) with controllable structures and properties. PolyHIPEs are almost always crosslinked to prevent collapse during polymerization, purification, and drying. Increasing numbers of applications require monolithic porous polymers with high surface areas. However, polyHIPEs possess specific surface areas (SSAs), as determined by the BET (Brunauer–Emmett–Teller) method, S_{BET} , that are typically less than $50 \text{ m}^2\text{g}^{-1}$. Polymers of intrinsic microporosity (PIMs), prepared using rigid and twisted monomers with steric groups that prevent conformational changes, are usually linear, and thus, processable. The poor molecular packing in PIMs produces microporosity and S_{BET} as high as $900 \text{ m}^2\text{g}^{-1}$, making PIMs of interest for gas storage, separations, and the adsorption of organic compounds. The chemistries and properties of PIMs can be fine-tuned using the wide variety of monomers and crosslinking comonomers available.

The objective of this investigation was to develop microporous-macroporous hierarchically porous polymer monoliths via the synthesis of crosslinked PIMs within oil-in-oil (o/o) HIPEs. The preliminary work focused on investigating the influence of both planar and rigid, twisted crosslinking comonomers on the porous structures and SSAs of the polyHIPE monoliths. Linear PIM reference materials, one based on a conventional PIM synthesis and the other on a synthesis that contained the internal phase but did not contain the surfactant exhibited S_{BET} of 723 and $315 \text{ m}^2\text{g}^{-1}$, respectively. It was possible to synthesize polymer monoliths based on PIM-like reactions within o/o emulsions when sufficient crosslinking comonomer was included. The S_{BET} of conventionally synthesized PIMs was, however, significantly reduced by the inclusion of a planar crosslinking comonomer and emulsion templating reduced the S_{BET} even further.



P -30

POROUS, EMULSION-TEMPLATED, BIODEGRADABLE POLYESTERS SYNTHESIZED USING RING-OPENING POLYMERIZATION

Samah Saied-Ahmad¹

*Department of Material Science and Engineering, Technion - Israel
Institute of Technology, Haifa, Israel*

The synthesis of porous biodegradable polyesters has attracted considerable attention owing to their suitability for biomedical applications such as tissue engineering and drug delivery. The objective of this research is to synthesize crosslinked biodegradable polyesters through the ring-opening polymerization (ROP) of cyclic monomers within oil-in-oil medium internal phase emulsions (MIPes) in which the 60% internal organic phase is silicone oil or a non-polar hydrocarbon. PolyMIPes were successfully synthesized from lactide, glycolide, and their copolymers using different crosslinking strategies (glutaraldehyde or bis-(ϵ -caprolactone-4-yl)) and different catalysis strategies (a metal-based catalyst or an organo-catalyst). The resulting densities, macromolecular structures, porous structures, thermal properties, and mechanical properties were characterized. Poly(L-lactide) (PLLA) and polyglycolide (PGA) exhibited interconnected pores ranging from 10 to 30 μm and a lower density (0.22 g/cm^3) than that of a poly(lactide-co-glycolide) (PLGA) (0.27 g/cm^3) that exhibited somewhat smaller pores. The stress-strain curves of the PLLA and PGA polyMIPes exhibited a linear elastic region and moduli of around 0.3 MPa, while the PLGA exhibited an elastomeric stress-strain curve and a modulus of 0.02 MPa. PLLA underwent complete hydrolytic degradation in 0.01 M NaOH within 4 h. These results suggest that such highly porous, biodegradable polyMIPe systems should be suitable for tissue engineering applications.



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A NOVEL SIZING FOR CARBON/EPOXY PREPREGS: FROM MICRO TO MACRO, FROM MANUAL WET LAYUP TO AUTOMATED PROCESSING

May Blau¹, Naum Naveh¹

*Department of Polymer Materials Engineering, Shenkar -
Engineering. Design. Art, Ramat Gan, Israel*

An epoxy-urethane water-based sizing system was applied to carbon fiber, then evaluated in a carbon/hot melt epoxy unidirectional towpreg. The study assessed the effect of sizing concentration, hot melt composition, the impregnation parameters and the curing conditions, on the micro and macro-mechanical properties of the composite. Preliminary work with manual impregnation was followed by automated processing in a modern impregnator. Characterization included thermal, chemical and wetting properties, mechanical behavior and morphology. The resulting prepregs can run in an Automated Fiber Placement (AFP) machine. The sizing contributes significantly to the shear strength and may also help extend the serviceability of carbon fibers.



P -32

SILKWORMS AS A NATURAL BIOPRINTING SYSTEM OF SILK FIBERS

Ori Brookstein, Eyal Shimoni, Dror Eliaz, Ulyana Shimanovich
Weizmann Institute of Science

Silk fibers are remarkable biomaterial utilized by various organisms, including spiders and silkworms to construct architectural marvels such as webs and cocoons. The fibers have a highly-ordered hierarchical structure that defines exceptional mechanical properties, including high strength, extensibility, and toughness. Natural silk production is a bioprinting process wherein a bio-ink (highly viscous liquid protein feedstock) flows inside the tubes (silk glands) and is extruded (spun) through the nozzle (spinneret/spigot) to fabricate a desired macroscale object, in an additive process. However, silk feedstock is not a standard "ink". During its processing, the feedstock changes its properties, and the protein fluid undergoes self-assembly and structural transitions, resulting in a structured material with remarkable physical characteristics.

In this study, we employ a combination of microscopy, analytical techniques, and rheology methods to investigate this natural bioprinting system and gain insights into silk fibers' material evolution and structure. Our findings provide valuable information regarding the in-vivo mechanism of the feedstock structural transitions and the resultant changes in physical properties. The comprehensive understanding of this process, is expected to inspire the development of novel bioprinting routes and material processing techniques aimed at creating structures with superior characteristics.



P -33

ENHANCING ADHESION STRENGTH OF 3D-PRINTED POLYMER JOINTS VIA ATOMIC LAYER DEPOSITION SURFACE MODIFICATIONS

Shachar Keren¹, Noy Cohen², Tamar Segal-Peretz¹

¹*Department of Chemical Engineering, Technion–Israel Institute of Technology, Haifa, Israel*

²*Department of Materials Science and Engineering, Technion–Israel Institute of Technology, Haifa, Israel*

Polymer-based materials have become common structural materials in many applications, such as aerospace and automotive, due to their low cost, lightweight, and ability to tailor their properties and geometry to specific needs. Load-bearing structures and joints, traditionally made of metals and alloys, are increasingly being replaced by polymer-based materials. While traditional metal joints are usually joined together via methods such as welding, brazing, and bolting, joining polymer-based materials requires an alternative method. Adhesive joints enable bonding between polymer-based materials and multi-material parts while attaining high mechanical performances and corrosion resistance. Moreover, adhesive bonding could be used as a cheap and fast technique for patch repair, thus reducing maintenance costs and time. Yet, using adhesives as a bonding technique for some polymers could be challenging due to low surface energy.

The current study presents a novel approach for enhancing polymer-based joints' adhesion strength and toughness by modifying the surface morphology and composition via atomic layer deposition (ALD). 3D-printed Acrylonitrile Butadiene Styrene (ABS) substrates were exposed to ALD processes to grow a nano-scale oxide layer on their polymeric surface (ZnO, AlOx, TiOx, or a combination of them). Two similar substrates were bonded with a 1 mm thick, soft adhesive to assemble a single lap shear joint. Shear measurements reveal that ALD-treated lap shears present an 80-110% increase in their shear strength compared to pristine lap shears. To capture the nano-scale mechanisms involved in the enhancement, we used atomic force microscopy (AFM), scanning electron microscopy (SEM), energy-dispersive spectroscopy (EDS), and contact angle measurements.



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FILTERING ELECTROMAGNETIC RADIATION IN SINGLE-SIDE DIODE-PUMPED SOLID-STATE LASER

Noam Lusthaus¹, Oren Regev¹

*Department of Chemical Engineering, Ben-Gurion University of the
Negev, Beer Sheva, Israel*

The laser's efficiency (defined as the ratio between the laser output and input powers) of a single-side diode-pumped solid-state is traditionally improved by applying a doped ceramic filtering layer that is supposed to (1) suppress the Amplified Spontaneous Emissions (ASE), and (2) reflect the non-absorbed incident "pump" light. However, their preparation is complex and results in bulky and heavy components (~3 mm thick). Therefore, spray-coated polymeric composite film (μm in thickness) is proposed. Usually, both optical requirements (mentioned above) contradict each other, which limits the filtering layer performance. For this purpose, the use of complex systems (e.g., Layer-by-Layer method) formed from distinct layers varying in composition, concentration, and thickness was suggested. For that, an examination of different parameters, such as concentration and thickness was made. Thereafter, the single-layer results were fitted to an appropriate model, which provided a prediction for the optical performance of complex systems. Those multilayer films were prepared and compared to the theoretical results. Herein, Nd:YAG lasers are used as a case study. That means the filtering layer requires to absorb the ASE of 1064 nm and reflect the incident "pump" light of 808 nm. Particles of trivalent Samarium species were used, due to their suitable absorption band in the near Infrared region.



P -35

MWCNT-REINFORCED SILICONE ELASTOMER COMPOSITES

Lev Rovinsky¹

*Department of Materials Science and Engineering, Tel Aviv
University, Tel Aviv, Israel*

Electrically conductive elastomer composites are one of the enabling concepts for applications such as wearable electronics, conformable sensors, and skin-monitoring. Said composites are fabricated by reinforcing elastomers with electrically conductive phases, such as carbon nanotubes (CNT). The main advantage of CNT is their low percolation threshold, reducing their required amount for substantial increase in electrical performance. The homogeneity of such composites can be impeccable in their bulk, excepting the outermost layer, which can contain no CNT all, and generate parasitic capacitance. In this work we present a hypothesis regarding the formation mechanism of such insulation layer, and investigate its morphological and dielectric properties.



P -36

HOW LOW CAN WE GO? ENHANCING POLYMER RESISTANCE TO SOLVENTS WITH GROWTH OF INORGANIC MATERIALS IN IT FROM VAPOR PHASE

Gilad Sasson¹, Tamar Segal Peretz

Department of Chemical Engineering, Technion - Israel Institute of Technology, Haifa, Israel

Polymer processes are often limited by the polymers solvent resistance capabilities and need to work around them. Sequential Infiltration Synthesis (SIS) is a process where a polymer sample is exposed to a vapor phase precursor and co-reactant sequentially. The precursor diffuses into the polymer, reacts and forms inorganic clusters inside the polymer. The growth of inorganics has demonstrated enhanced polymer solvent resistance and controlled growth via functional group concentration.

In this study, we ask if polymer film resistance to organic solvent be achieved with low concentration of functional groups that react in SIS? To that end, we have used PS-random-PMMA copolymers and varied the fraction of the reactive PMMA to control the level of Al₂O₃ growth within the polymer. We show that while nucleation of Al₂O₃ is linearly correlated to PMMA fraction, additional Al₂O₃ growth at high cycle number occurs at higher rates at lower PMMA fractions due to the reduced diffusion of trimethyl aluminum (TMA) at high Al₂O₃ concentration of the hybrid film.

We show the relation between the enhanced solvent resistance and the functional group densities within the polymer films. As expected, pure PS films that lack reactive groups remained immediately dissolved by toluene, even after SIS treatment, while pure PMMA films showed excellent resistance to dissolution. High resistance to dissolution by toluene was observed also in the PS-r-PMMA films after Al₂O₃ SIS. Interestingly, PS-r-PMMA samples with as little as 9% PMMA displayed excellent resistance to dissolution after SIS. This indicates that ~10% of well dispersed Al₂O₃ within the polymer is sufficient for creating the protecting inorganic cross-linking and maintaining the films stability in organic solvents.



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EMERGENT SELF-ASSEMBLY OF SUSTAINABLE PLASTICS BASED ON AMINO ACID NANOCRYSTALS

Dr. Haim Weissman¹, Angelica Niazov-Elkan¹, H. Daniel Wagner¹,
Boris Rybtchinski¹, Eyal Shimoni², XiaoMeng Sui², Yishay
Feldman²

¹*Dept. of Molecular Chemistry and Material Science, Weizmann
Institute of Science, Rehovot, Israel*

²*Dept. of Chemical Research Support, Weizmann Institute of
Science, Rehovot, israel*

Development of biodegradable plastic materials is of highly importance in view of critical health and environmental problems related to the accumulation of plastic waste. We fabricated a biodegradable composite material based on hydroxyethyl cellulose polymer and tyrosine nanocrystals, which demonstrated enhanced strength and ductility that are superior to most biodegradable plastics. This intriguing emergent behavior came forth from an assembly pattern that lead to a uniform nanoscale morphology and robust interactions between its components. We also demonstrated the feasibility of water-resistant biodegradable composites that were obtained by encapsulation with hydrophobic polycaprolactone as a protection. Our work brings forward a valuable toolbox for creating robust sustainable materials with emergent properties by self-assembly of readily available building blocks.

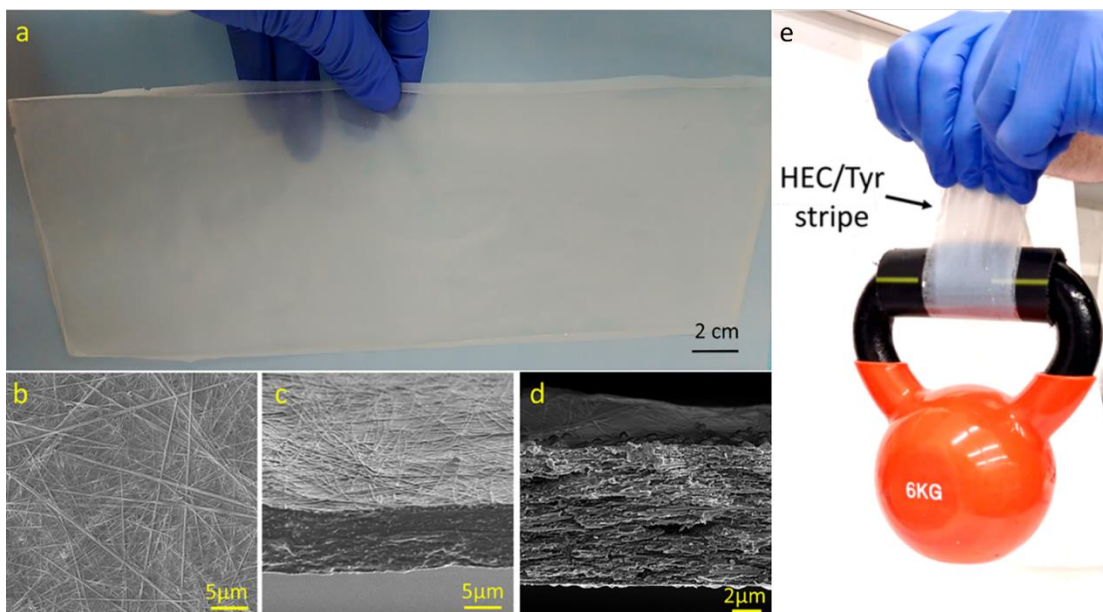




Figure 1. HEC/Tyr (10:3, wt %) film. (a) A photograph of the film. (a–c) SEM images: (b) top view; (c) cross section; (d) zoomed-in image of the cross section; (e) HEC/Tyr (10/3, w/w) hybrid stripe, 40- μm thick, lifting 6-kg weight.

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P -38

UNLOCKING NEXT-GEN POLYOLEFIN DEGRADATION BY HEAT-RESISTANT DOUBLE EMULSIONS

Antolin Jesila Jesu Amalraj¹

Food science, Volcani Institute, Rishon leTzion, Israel

Our project aims to revolutionize spore encapsulation within emulsions, enhancing heat resistance to ensure spore viability amidst plastic hydrolysis. Utilizing O/W/O emulsions, we combine paraffin oil and an aqueous phase stabilized with hydrophilic and hydrophobic silica, achieving exceptional encapsulation efficiency (96.5%) of 6-micron *Conidia* spores in droplets of 10 μm and 124 μm . Visual confirmation through Confocal 2D/3D, SEM, and Cryo-SEM images verifies spore encapsulation in both single and double emulsions. Viability tests reveal a noteworthy 12% retention of colony-forming units (CFU) even after 100 days. Our milestone achievement involves successfully extruding emulsion-spore blends with LDPE, ensuring survival of emulsion droplets and encapsulated spores at 120°C, attributed to the remarkable structural stability and viscoelastic properties of the O/W/O emulsion. We initially selected fungal spores for the pilot formulation due to their ease of experimentation. Subsequently, we transitioned to bacteria, the actual plastic degrader, within the system to achieve our goal where the degradation of polyolefin was confirmed through FT-IR analysis. This breakthrough not only introduces a novel spore encapsulation method but also presents a groundbreaking approach to spore preservation during plastic processing, promising transformative impacts across various industries.



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CELLULOSE-COATED OIL IN WATER EMULSIONS AS MICRO-REACTORS: STRUCTURAL CHARACTERIZATION AND BIO-PROCESSING OF CELLULOSE TO BIODIESEL

Ester Korkus Hamal, Gilad Alfassi, Dmitry M. Rein, Yachin Cohen

Concerns about increasing energy demands as fossil fuel reserves are reduced and severe environment concerns encourage the development of renewable alternative raw materials for fuels. One potential alternative to petroleum-based fuels is biodiesel. Our study is part of an overall objective to convert cellulose from pretreated biomass directly to bio-diesel, using cellulose-coated emulsion particles as micro-reactors for a cascade of biochemical reactions in a “one-pot” consolidated process. Integration of cellulose-coated oil in water (o/w) emulsion with yeast (*S. cerevisiae*) cell expose a unique self-assembly configuration. Fluorescence microscope imaging and cryo-SEM imaging provide evident to an integrated structure of cellulose-coated micro-particles attached to the yeasts’ surface. This integrated structure is used for simultaneous cellulose saccharification and fermentation to ethanol. Furthermore, it presents a “proof-of-concept” for the crucial step in this process: the ability of lipase integrated within o/w emulsion particles encapsulated by natural cellulose, to catalyze transesterification of the encapsulated oil with ethanol dissolved in the aqueous medium. The activity of lipase-catalyzed transesterification is studied by using NMR quantification of FAEE while different conditions such as oil to ethanol molar ratio, lipase concentration and temperature were examined. It is expected that the results of this study, will provide the complete transformation of cellulose to biodiesel by enzymatic hydrolysis, yeast fermentation and lipase-catalyzed transesterification, in a single emulsion-based consolidated bio-process.

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P -40

UNMASKING THE BIODEGRADATION PROCESS: EXPLORING VOC EMISSIONS AND MICROBIOME DYNAMICS IN PLASTIC-SOIL INTERACTIONS

YANCUI LIANG^{1,2}, Yancui Liang^{1,2}, Yuping Cao^{1,2}, Jiani Xing¹, Chenhao Zhao¹, Yiyun Cai¹, Liwen Zhang¹, Zeshen Xiao¹, Avishay Levy¹, Dganit Danino³, Yoav Eichen³, Yigal Achmon³

¹*Department of Biotechnology and Food Engineering, Institute of Technology, Guangdong, China*

²*Department of Biotechnology and Food Engineering, Technion, Haifa, Israel*

³*Department of Biotechnology and Food Engineering, Technion, Haifa, Israel*

The production of plastics has increased steadily, reaching 460 million tonnes by 2019. This surge in production has led to a significant accumulation of plastic waste across various industrial sectors. However, only a small fraction, less than 10%, of this plastic waste was recycled, with the majority ending up in landfills or being mismanaged. The vast amount of plastic residue poses potential ecological and health risks to the environment. A comprehensive literature review has revealed limited attention given to assessing the profiles of volatile organic compounds (VOCs) during the degradation of plastics in soil, which can be correlated with the dynamics of the soil microbiome. This research aims to contribute to a more systematic and in-depth understanding of the biodegradability of common plastics (both conventional and biodegradable).

Following a 90-day lab-scale aerobic simulation, our findings indicate significant changes in the emission profile of volatile organic compounds (VOCs) upon the introduction of poly (butylene-adipate-co-terephthalate) (PBAT) residue into the soil. This alteration potentially leads to the production of hazardous compounds such as 1,3-Butadiene. Additionally, significant ethylene production was observed in Polyethylene (PE) and Poly lactic acid (PLA) during the incubation period. Microbial analysis further revealed a differential response to PBAT, with the genera *Hydrogenispora* and *Streptomyces* showing a positive correlation with specific VOCs. Our study offers new insights into plastic biodegradation, facilitating a deeper assessment of their degradation processes.



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NEMO NANO MATERIALS DEVELOPS AND MANUFACTURES WELL-DISPERSED CONCENTRATES BASED ON SINGLE-WALLED CARBON NANOTUBES HYBRIDS.

Jonathan Antebi

Department of Marketing, Nemo Nanomaterials, Petah Tikva, Israel

Nemo Nano Materials develops and manufactures well-dispersed concentrates based on Single-Walled Carbon nanotubes hybrids. Nemo's materials are ready-to-use solutions for existing industrial equipment enabling a new set of properties like lightweight Carbon-based EMI shielding in plastics, electrical conductivity, and more.

The high efficiency of the masterbatches is achieved through a combination of unique formulation and processing technology, enabling outstanding dispersion within the ultimate application.

NemoBlend™ masterbatch is designed to achieve controlled electrical conductivity in different thermoplastic polymers such as PA, PP, PS and PE for extrusion or injection molding applications. Subject to the designed process and dosing rate, the NemoBlend™ masterbatches may provide volume resistivity between 10^2 - 10^8 ($\Omega \cdot \text{cm}$).

Nemo's EMI shielding solutions apply to a variety of polymer types. The increasing complexity & prevalence of advanced electrical components in a variety of products, growing connectivity, and the move to advanced communication networks – creating significant EMI challenges to manufacturers from leading industries: automotive, aerospace, telecom, electronics, defense, and more.

NemoBlend™ masterbatches also offer industry ready-to-use processability, long runs with no die buildup, and can be mixed with dark color masterbatches to obtain colored products.



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SWITCHABLE THERMOSETS: TOWARDS SUSTAINBLE ADHESIVES` FUTURE

Rachel Avshalomov¹, Natanel Jarach^{1,2}, Hanna Dodiuk¹

*¹Polymer Materials Engineering, Shenkar – Engineering. Design.
Art, Raman-Gan, Israel*

*²Chemistry and Center for Nanoscience and Nanotechnology,
Hebrew University of Jerusalem, Jerusalem, Israel*

Adhesives with polymeric bases are indispensable in joining various surfaces across numerous industries and applications. The recognition of environmental concerns and the demand for sustainable materials has spurred researchers to explore innovative strategies for improving the recyclability of polymeric adhesives. These adhesives are mostly thermosets-based, thus, infusible and insoluble in nature. Therefore, potential solutions were explored, such as implementing covalent adaptable networks (CANs) in thermoset adhesives to enable their recycling. This dynamic covalent bond allows for the reuse of the material by reversing the crosslinking in the polymer under specific stimuli and conditions, and re-crosslinking under different conditions. Various stimuli, such as thermal, light, and pH, can generate reversible bonding and debonding.

This study utilizes dynamic disulfide bonds to develop light-responsive adhesives through radical reactions of thiols to disulfides in the presence of photoinitiators. Crosslinking was achieved within 10 minutes under 395 nm UV light with catalysts, and within 4 minutes under 365 nm UV light without catalysts. To enhance the system, various mole ratios of the components were tested.

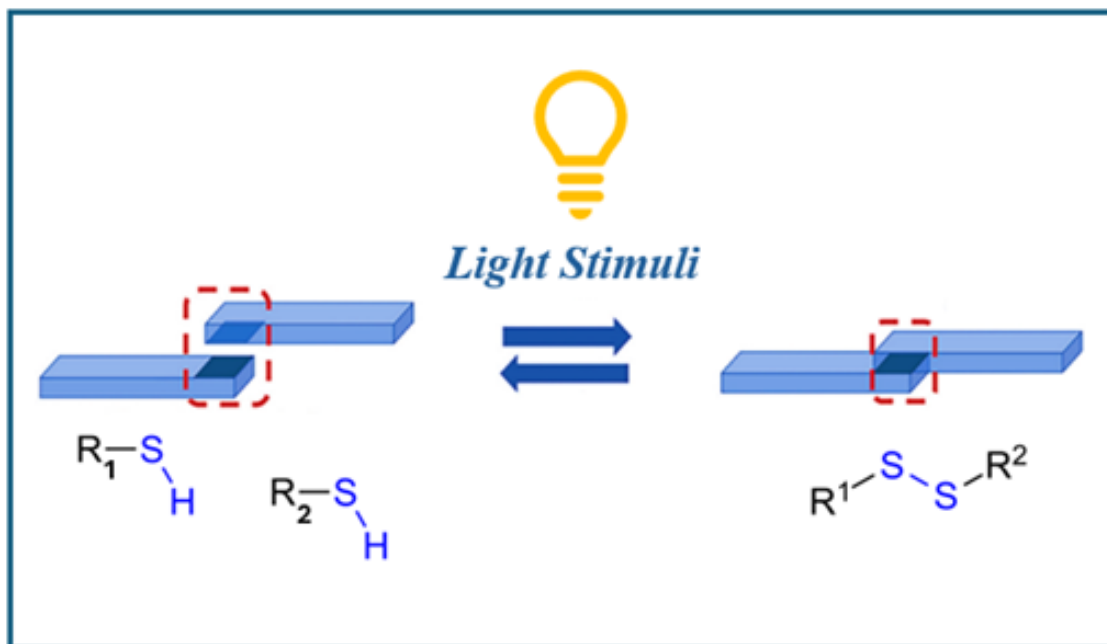




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CONVERT TEXTILE WASTE INTO UPCYCLED ENGINEERED COMPOUND, WITH REQUIRED PERFORMANCES.

Lee Cohen

The textiles industry is the second largest polluting industry in the world; it generates over 100m tons of waste annually that being landfilled or incinerated, while over 60% are consist from polyester fiber. On the other hand, different industries seek a replacement for their use in high CO2e materials, derived from fossil fuels.

TextRe provides an innovation technology and process to utilize textile waste into upcycled engineered materials, to be used in various premium applications and industries. By that, TextRe is changing the textile industry from a polluter to a producer of circular economy.

Our solution includes double climate impact, reducing textile waste being landfilled and offering to the compound and plastics industries a sustainable and price-competitive substitute for using virgin polymers – but with the same required characteristics.

Our process includes several phases the consists our holistic solution and our proprietary IP.

We have accomplished our first prototype of a compound, that is already today consists of 50% recycled textiles and demonstrated reduction within 50% in GHGe. We have produced a first prototype of a coat hanger made from TextRe`s compound.



We invite you to follow our exciting development and achievements.



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COMPATIBILIZATION OF POLYMER BLENDS WITH POLY (B-HYDROXY ESTER) VITRIMER

**Karin Rosenfeld, Natanel Jarach, Hanna Dodiuk, Shmuel Kenig,
Naum Naveh**

With the increasing consumption of non-biodegradable polymers and plastics, there is a growing attempt to find solutions to their negative environmental impact.

To date, biodegradable polymers do not provide a satisfactory solution as they have less favorable properties than their non-biodegradable counterparts.

Vitrimers are a novel family of polymers that contain reversible chemical bonds which allow for reprocessing and recyclability (something that is not possible in thermosets), and provide superior mechanical properties compared to common thermoplastics.

In this project, different types of organometallic catalysts were used to study the effect of crosslink density on the viscosity of Vitrimers, then reduce the viscosity of a poly (β -hydroxy-ester) vitrimer to optimize its processing.

After analyzing the results by rheological, thermal, and swelling tests, the vitrimer with the lowest viscosity was processed with recycled polyethylene/polypropylene (PE/PP) and plastic waste from multi-layer films. The vitrimer-modified polymer blends exhibit high flow and excellent properties including impact strength.

The better processability will lead to higher throughputs and enable the commercialization of a vitrimer compatibilizer for polyolefins (polyethylene, polypropylene), the most common polymers in domestic and industrial consumption.



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ASSESSING THE ENVIRONMENTAL IMPACT OF VITRIMERIC ENCAPSULATION FOR PHASE CHANGE MATERIALS: A PROSPECTIVE LIFE CYCLE ASSESSMENT

Amir Shefy¹, Sabrina Spatari¹, Pieter Billen², Philippe Nimmegeers²

¹*GTEP, Technion - Israel Institute of Technology, Haifa, Israel*

²*iPRACS, University of Antwerp, Antwerp, Belgium*

Vitrimers, a novel class of materials featuring dynamic covalent bonds, have attracted significant interest as "green" polymers due to their combination of properties and recyclability, all while maintaining stability through multiple reprocessing cycles. Nevertheless, the environmental impact of vitrimers is still unknown. To address this knowledge gap, this work presents a broad assessment of the environmental performance of phase change material (PCM) encapsulation processes through life cycle assessment (LCA). Commercial micro- and macro-encapsulation technologies were evaluated and compared to innovative vitrimeric encapsulation for paraffin waxes derived from petroleum and pyrolyzed recycled polymeric feedstock. The environmental performance of vitrimeric encapsulation achieved by grafting functionalized dioxaborolane maleimide on paraffin wax is studied. Compared to other encapsulation technologies, in terms of global warming intensity, vitrimeric encapsulation showed poor results, with 5683 kg CO₂eq for the encapsulation of 1-ton PCM compared to 1107 kg CO₂eq for current HDPE encapsulation systems on the market. Moreover, vitrimeric encapsulation impact was the highest among other impact categories. While the assessment was facing data limitations, it contributes to a better understanding of the environmental impacts of producing such an innovative encapsulation material. Furthermore, this LCA emphasizes the need for future research on the environmental performance of vitrimeric materials as well as studying the complex trade-offs associated with their manufacturing process and avoided burdens.



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**DIRECTED SELF ASSEMBLY (DSA) OF BLOCK COPOLYMER
MICELLES, EFFECT OF PATTERN CHARACTERISTICS ON MICELLE
DIAMETER AND MICELLE DENSITY**

Riham Muzaffar Kawasma¹, Prof. Roy Shenhar¹
Chemistry, The Hebrew University, Jerusalem, Israel

In this study, we explore the assembly of polystyrene-block-poly(2-vinyl pyridine) (PS-*b*-P2VP) micelles on topographically defined substrates featuring parallel trenches and plateaus with varying widths and trench depths. One of the main differences between the assembly of spherical particles, such as silica and latex particles, and micellar structures, is that block copolymer micelles are soft and not cross-linked, so they change their shape when deposited on a substrate. Hence, we were curious to investigate how their structure would respond to topographically patterned substrates.

We have found that capillary forces acting during the casting lead more material to deposit in the trenches than on the plateaus, leading to different micelle density on the plateaus and in the trenches. We quantified the amount of material in terms of the number density of micelles.

The micelle density in the trenches is always higher than that on the plateaus. Thus, micelles in the trenches are more densely packed; as a result, they also display smaller average diameters compared to those deposited on the plateaus. Moreover, micelle density in the trenches is found to be largely independent on the trench width, whereas the density on the plateaus exhibits a slight linear dependence on the plateau width. The average micelle density and diameter on a flat region of the substrate are intermediate between the values determined on the topographic features, attesting to the ability of the micelles to accommodate their dimensions to their local spatial confinement. The trench depth effect is also being investigated.



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FROM LIQUID PROTEIN TO SOLID ARTIFICIAL SILK FIBER WITH PROGRAMMABLE PROPERTIES

**Mariia Rodionova¹, Aleksei Solomonov¹, Dror Eliaz¹, Ulyana
Shimanovich¹**

*Department of Molecular Chemistry and Materials Science,
Weizmann Institute of Science, Rehovot, Israel*

This research addresses the problem of silk fibrous waste pollution by developing a sustainable method for the reconstitution of silk fibroin from defective cocoons and reconstructing the protein into a morphology mimicking natural silk fiber in terms of appearance and mechanical properties.

A platform for wet-spinning artificial silk fibers was developed to achieve this scientific goal. The research result will be an understanding the fundamental mechanisms of spinning fibrillar proteins into continuous solid fibers with controllable mechanical properties.