# Farewell and 70th Birthday of **Prof. Dr. Oğuz Okay**

## Workshop Booklet

2025

CROSSLINKED

IN HONOR OF PROF. DR. OĞUZ OKAY

**Invited Speakers:**

Prof. Dr. Vladimir Lozinsky
Prof. Dr. Heikki Tenhu
Prof. Dr. H. Yıldırım Erbil
Prof. Dr. Nurettin Şahiner
Prof. Dr. Amitav Sanyal

Supported within the scope of TÜBİTAK 2223-B – Grant Program

2025

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# Welcome
# Message

Dear Colleagues,

On behalf of the Organizing Committee, it is my pleasure to welcome you to CROSSLINKED 2025, a one-day workshop focusing on crosslinked polymer systems and their applications.

The first CROSSLINKED Workshop was held in 2007 at Istanbul Technical University, and now, after many years, we are delighted to organize the second in this series to celebrate the 70th birthday of Prof. Okay, whose pioneering research has made a profound impact on polymer networks.

The program will feature state-of-the-art talks on the design, synthesis, and characterization of crosslinked polymer systems, panel discussions addressing sustainability and future perspectives in polymer research, and special sessions dedicated to Prof. Okay's scientific legacy. We hope this event will provide both an inspiring scientific platform and a meaningful tribute to an outstanding scientist and mentor.

We look forward to welcoming you to CROSSLINKED 2025 and sharing an engaging and memorable day with our polymer community.

Warm regards,
**Prof. Dr. Deniz CEYLAN**

Chair, CROSSLINKED 2025
On behalf of the Organizing Committee

# Prof. Dr. Oğuz Okay

- Prof. Oğuz Okay (born in 1955, Istanbul) is a **world-renowned scientist** in the fields of **polymer chemistry and smart materials**.
- He graduated from **Istanbul University, Department of Chemical Engineering in 1977** with a degree in Chemical Engineering, and **in the same year** received a **TÜBİTAK scholarship to pursue his doctoral studies abroad**.
- He joined the Institute of Macromolecular Chemistry at the Vienna University of Technology, where he earned **a second master's degree in 1978** and a **Ph.D. in Polymer Chemistry in 1981**.
- Following his doctoral studies, he returned to Turkey and began his academic career, obtaining the title of **Professor at Kocaeli University**.
- Between 1992 and 1995, he served as a **Senior Research Scientist at the Chemistry Department of TÜBİTAK Marmara Research Center**, where he carried out research on polymer materials.
- He later joined the **Department of Chemistry at Istanbul Technical University (ITU) in 1998**, where he continued his teaching and research until his retirement. At ITU, he led the Okay Research Group, which focused on advanced material systems such as **hydrogels, cryogels, self-healing materials, and shape-memory systems**.

# Prof. Dr. Oğuz Okay

- His studies have had a significant impact in both fundamental science and applied material design, bridging chemistry, materials science, and biomedical engineering. Throughout his career, Prof. Okay has published over **220 scientific papers**, accumulating **approximately 11670 citations with a Web of Science h-index of 58 and 16000 citations in Google Scholar, with an h-index of 71**.

- He is also the holder of four patents and has received numerous national and international awards for his scientific achievements. Among his most prestigious awards are the TÜBİTAK Science Award (2005), the Sedat Simavi Science Award, TÜBİTAK Incentive Awards, and the Alexander von Humboldt Research Fellowship. Prof. Okay is also an elected full member of the Turkish Academy of Sciences (TÜBA).

- As a distinguished academic, Prof. Okay is widely recognized for his pioneering contributions to both fundamental polymer science and applied material technologies. His research not only advances the scientific understanding of polymeric systems but also inspires young scientists working in the field of advanced functional materials.

# Invited Speakers

## Prof. Dr. Vladimir I. LOZINSKY

Prof. Dr. Vladimir I. Lozinsky graduated from the Moscow Institute of Fine Chemical Technology in 1971, specializing in the chemical technology of biologically active compounds. He earned his PhD in Organic Chemistry in 1982 and his DSc in Macromolecular Chemistry/Biotechnology in 1994 with a thesis on cryogels. He has served in various research positions at the Russian Academy of Sciences and has been the Laboratory Director at the Institute of Organoelement Compounds since 1996. His research focuses on cryogenic processes in polymer systems, including cryostructure formation, cryopolymerization, and their applications in biotechnology, biomedicine, and materials science. He has authored over 500 scientific works, holds around 70 patents, and has coauthored two textbooks. As of October 2025, his 90 publications have received over 2,000 citations in Web of Science.

## Prof. Dr. Heikki TENHU

Professor Heikki Tenhu received his Ph.D. in Polymer Chemistry from the University of Helsinki in 1985, where he currently serves as Professor of Polymer Chemistry. His research focuses on stimuli-responsive polymers, self-assembly, controlled/living polymerization, and nanostructured materials. He has made significant contributions to temperature- and pH-responsive polymers and polymer–surface interactions, with applications in drug delivery, smart coatings, and advanced materials. He has published over 250 scientific papers and, as of October 2025, his work has received more than 14,200 citations in Google Scholar, with an h-index of 61. His group's work has had a lasting impact on the design of functional polymer systems for biomedical and technological applications.

# Invited Speakers

## Prof. Dr. Yıldırım ERBİL

Prof. Dr. H. Yildirim Erbil graduated from Istanbul University with a degree in Chemical Engineering in 1977, obtained his MSc from Aston University in 1978, and his PhD from Istanbul Technical University in 1985. He conducted 12 research projects supported by TÜBİTAK, the European Commission, and the NSF, and supervised 38 MSc and 13 PhD theses. His research focuses on wetting, contact angles, polymer surface modification, droplet evaporation, and the development of superhydrophobic and anti-icing surfaces. He has authored two books, three book chapters, and more than 90 international papers, mostly published in ACS and RSC journals. As of October 2025, his work received more than 10,700 citations in Google Scholar, with an h-index of 44.

## Prof. Dr. Nurettin ŞAHİNER

Prof. Dr. Nurettin Şahiner completed his undergraduate studies at Hacettepe University and his PhD in Chemical Engineering at Tulane University, USA, followed by postdoctoral research at the University of Delaware and Tulane University School of Medicine. He joined Çanakkale Onsekiz Mart University, where he became a professor in 2015. He received the TÜBA-GEBİP Award in 2008 and the TÜBİTAK Science Incentive Award in 2011. He was ranked 25th among the 100 Turkish Researchers Leading the Field of Chemistry by Turkishtime in 2021. His research covers materials science, polymers, hydrogels, nanotechnology, and biomaterials. He has over 300 publications and 16 patents. As of October 2025, his works have received more than 15,000 citations in Google Scholar, with an h-index of 67.

# Invited Speakers

## Prof. Dr. Amitav SANYAL

Prof. Dr. Amitav Sanyal received his integrated bachelor's and master's degrees from the Indian Institute of Technology, completed his PhD in Organic Chemistry at Boston University, and conducted postdoctoral research in polymer chemistry and self-assembled nanomaterials at UMass Amherst. A faculty member at Boğaziçi University since 2004, he has supervised 16 PhD and 38 MSc theses. He received the TÜBA-GEBİP Award (2008), TÜBİTAK Incentive Award (2011), and multiple BUVAK Awards for excellence in education and research. His research focuses on organic, polymer, and materials chemistry, biomaterials, biosensors, and nanostructures. He has about 175 publications with nearly 5,200 citations in the Web of Science. According to Google Scholar, his works have received over 6,500 citations, with an h-index of 49.

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# Workshop Program

**09:00 - 10:00** **REGISTRATION:**

- Welcome Snacks

**10:00 – 10:30** **OPENING CEREMONY:**

- ITU Rector Prof. Dr. Hasan Mandal
- Head of Department/Faculty
- Chair Prof. Deniz CEYLAN

**10:30 – 12:00** **INVITED LECTURES:**

- **10:30 – 11:00.** Prof. Vladimir LOZINSKY
- **11:00 – 11:30.** Prof. Yıldırım ERBİL
- **11:30 – 12:00.** Birthday Wishes

**12:00 – 12:15** **BREAK – PHOTO TIME**

**12:15 – 13:30** **LUNCH BREAK**

**13:30 – 15:00** **INVITED LECTURES:**

- **13:30 – 14:00.** Prof. Heikki Tenhu
- **14:00 – 14:30.** Prof. Amitav SANYAL
- **14:30 – 15:00.** Prof. Nurettin ŞAHİNER

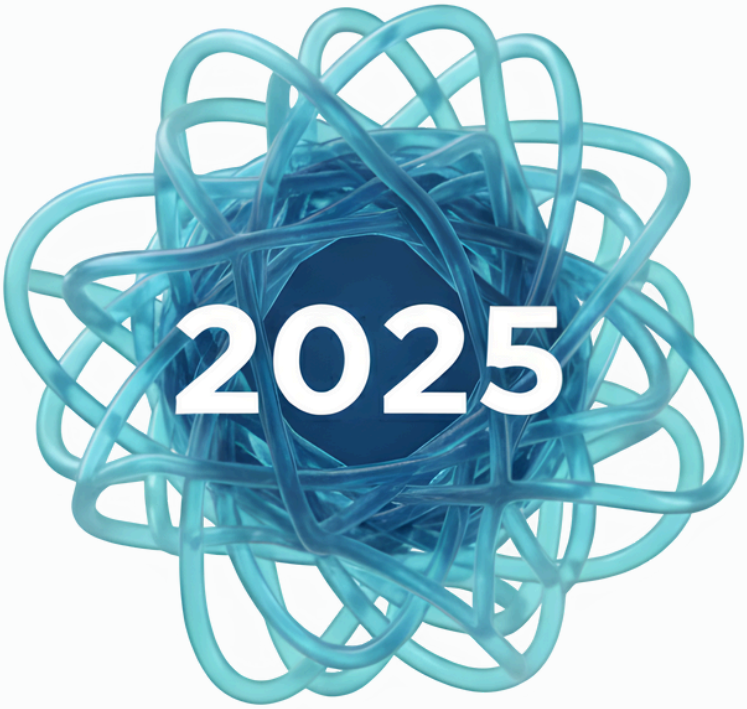
**15:00 – 16:00** **BREAK – POSTER SESSION**

**16:00 – 17:30** **TALKS:**

- **16:00 – 16:30.** Family
- **16:30 – 17:00.** Group Members
- **17:00 – 17:30.** General Speeches

**16:00 – 17:30** **CLOSING CEREMONY:**

- Prof. Dr. Oğuz OKAY

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# Invited Lectures

# DMSO-Containing Poly(Vinyl Alcohol) Cryogels As The Tools For Cleaning Of Artworks Upon Their Restoration

V.I.Lozinsky [1], O.Yu.Kolosova [1], L.V.Barannikova [1],
Yu.V.Ivanova [2], T.T.Chalenko [2], E.V.Aleshkina [2]

[1] *A.N.Nesmeyanov Institute of Organoelement Compounds, Russian Academy of Sciences, Moscow, Russian Federation*
[2] *State Scientific Institute of Restoration, Russian Ministry of Culture, Moscow, Russian Federation*

**Abstract**

Cryogels based on poly(vinyl alcohol) (PVACGs) are known for more than 40 years. These macroporous gel materials are formed, when concentrated solutions of the polymer are frozen, incubated for certain time in a frozen state and then are defrosted. Such cryogenic treatment promotes the interchain hydrogen bonding, thus causing the formation of polymeric microcrystalytes that perform as the knots of supramolecular network in the resultant PVACGs.
At the present time, a lot of examples for the application of these gel matrices are known, especially in such fields as biotechnology, biomedical materials, as well as the materials for the engineering aims. In recent years, PVA cryogels attract increasing interest in the technology of restoration of cultural heritage works. This direction of the restoration procedures was firstly developed about 15 years ago by the specialists from the University of Florence, who used PVACGs prepared from the aqueous PVA solutions in order to clean works of art from certain unwanted contaminants.
It is a rather clear that aqueous cryogels are capable of facilitating the removal of hydrophilic impurities from the contaminated surfaces, but similar gels are almost ineffective at removing organo-soluble impurities. To solve such a problem we suggested to restorers trying to use PVA cryogels, in which the dispersion medium is the organic solvent dimethylsulfoxide (DMSO) or its mixtures with other organic liquids.
The performed tests gave rise the following results:
The use of DMSO-containing PVA cryogels as the tools for revealing/cleaning artworks of cultural and historical heritage allowed successful restoration operations with such artworks that are difficult to clean using “aqueous” PVACGs.
The effectiveness of “organic” PVA cryogels has been proven during restoration of various types of cultural heritage objects, including easel tempera and oil paintings, three-dimensional gilded wood carvings, etc., thus demonstrating wide possibilities of such gel materials in terms of their versatility.
Developed “organic” PVA cryogels had good adhesion to the treated surfaces, which allowed these materials to be used when operating with vertical and three-dimensional surfaces.
It was possible and easy to prepare these cryogels with varying degrees of plasticity/elasticity, which expands the possibilities for their application in revealing surfaces with different textures/unevenness.
DMSO-containing PVA cryogels, unlike gels based on biopolymers, are not damaged by microorganisms.

***Acknowledgements:*** *The approach dealing with the use of the DMSO-containing poly(vinyl alcohol) cryogels as the tools for cleaning of artworks upon their restoration is now under patenting [Russian Patent Application # 2024135825 (079524), priority date 29.11.2024].*

**Functionalised Nanogels**

Heikki Tenhu

*University of Helsinki, Finland*

## Abstract

Poly(N-vinylcaprolactam), PNVCL, is a biocompatible [1] water soluble LCST polymer. Thanks to our collaborations we received the first samples of the polymer in 1998 and started to investigate it with light scattering [2-4]. Since the early studies we have several times come back to this interesting polymer.
Responsive polymers have been much studied to be used as carriers for active substances. We have tested nano/microgels of PNVCL and paid special attention on the colloidal stability of the gel particles. Dispersions of sterically stabilised particles have turned out to be stable even in saturated salt solutions [5].
Nano/microgels have recently been synthesised using MADIX polymerisation in polymerisation induced self- assembly (PISA) reactions. The vesicular particles were crosslinked via hydrogen bonding by complexing the polymer amide functions with salicylic acid [6].
PNVCL gel particles have been further functionalised with gold nanoparticles on the surfaces. AuNPs make the particles respond to not only temperature but also light and RF-field [7]. Another type of functionalisation was realised by clicking glucose or maltose to the gel particles. Binding of a model lectin to the particles was studied under varying conditions [8].

## References

[1] Cytotoxicity of thermosensitive polymers poly(N-isopropylacrylamide), poly(N-vinylcaprolactam) and amphiphilically modified poly(N-vinylcaprolactam). H. Vihola, A. Laukkanen, L. Valtola, H. Tenhu, J. Hirvonen; Biomaterials 26 (2005) 3055-3064
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[8] Glucose and maltose surface functionalized thermoresponsive poly(N-vinylcaprolactam) nanogels. J. Siirila, S. Hietala, f. S. Ekholm, H. Tenhu. Biomacromolecules 21 (2020) 955-965

**Short History Of Hydrogels And Prof. Oguz Okay's Initial Contributions On Hydrogels And Crosslinked Networks Between 1992-1996 In TUBITAK.**

Prof. Dr. H. Yıldırım Erbil *

** Retired from Gebze Technical University, Chemical Engineering Department*

**Abstract**

The first article on synthetic hydrogels was published by the late Czech chemists Professor Otto Witcherle and Professor Drahoslaw Lim in Nature journal in 1960 on the synthesis of poly(2-hydroxyethyl methacrylate) contact lenses. There are two sections in this presentation, the short history of hydrogels will be summarized including the interesting story of founding the contact lens industry by the initial activities of both Witcherle and Lim in the first part. In the second part, Prof. Oguz Okay's initial contributions on hydrogels and crosslinked networks field while he was working as a researcher in the Chemistry Research Institute of TUBİTAK-Marmara Research Center in Gebze, Kocaeli between 1992-1996 will be summarized. Prof. Okay published several experimental and theoretical articles during this period while he was working intensively with only a few students in his small laboratory, which was built from scratch with his own initiative. Only seven of these articles will be briefly discussed with their importances in the field.

## Diverse Applications Of Cryogels Prepared From Synthetic And Natural Polymers

Nurettin Sahiner [1,2]

[1] *Department of Chemical Engineering, Faculty of Engineering, Canakkale Onsekiz Mart University Terzioglu Campus, Canakkale, 17100, Turkey.*
[2] *Department of Bioengineering, U. A. Whitaker College of Engineering, Florida Gulf Coast University, Fort Myers, 33965, FL, USA.*

*sahiner71@gmail.com; nsahiner@fgcu.edu*

**Abstract**

Extensive research on the mechanisms of cryogel formation in the frozen states of polymeric systems and their characterization by V. I. Lozinsky and O. Okay provided key insights and tools for many researchers as basis to develop innovative materials with intriguing properties with an immense application potential. Cryogels afford remarkable mechanical properties, including elasticity, toughness, and strength, in addition to tunable pore features such as high porosity, interconnected and/or aligned pores, and a large surface area. These characteristics make cryogels highly adaptable and ideal materials for applications in many fields including energy, environment, sensing, biomedicine and so on.
This talk will address the application of cryogels derived from both natural and synthetic polymers and their composites for in situ synthesis of metal nanoparticles in catalytic applications and as templates for the direct synthesis of conductive polymers for sensor technologies. Additionally, it will examine the role of cryogels in the separation of environmental contaminants as well $CO_2$ capture technologies. Finally, the discussion will extend to biomedical uses of cryogels, including tissue engineering, artificial organs, wound dressings, drug delivery, and related fields.

***Keywords:*** *Synthetic/Natural Polymeric Cryogels, Cryogels Composites; Cryogel In Energy/Environment/Sensor/Biomedical Application*

**Design & Applications of Redox-responsive Polymeric Hydrogels: A Journey from Nano to Bulk Materials**

Amitav Sanyal [1,2]

[1] *Department of Chemistry, Bogazici University, Bebek, 34342, Istanbul, Turkey*
[2] *Bogazici University Center for Targeted Therapy Technologies, Bogazici University, Istanbul, Turkey*

**Abstract**

Stimuli-responsive polymeric materials, including nanogels, microgels, and bulk hydrogels, continue to shape the landscape of modern diagnostics and therapeutics. Building on the foundational advances that have defined this field, our work explores how dynamic chemical processes can be harnessed to achieve precise, reversible control over material behaviour. In this lecture, I will present our recent efforts in designing thiol–disulfide exchange-based–based polymer architectures across multiple length scales, from nanoscale assemblies to macroscopic hydrogel networks. Using fabrication approaches such as self-assembly, microfluidics, and cryogelation, we generate materials with finely tunable responsiveness and function. I will highlight applications that exemplify the versatility of these systems, including on-demand protein and cell capture and release, as well as stimuli-triggered delivery of therapeutic payloads. Together, these studies illustrate how simple yet powerful organic transformations can be leveraged to create next-generation functional hydrogels and related soft materials, advancing the vision and enduring impact of the pioneering contributions of Prof. Oğuz Okay, which we celebrate today.

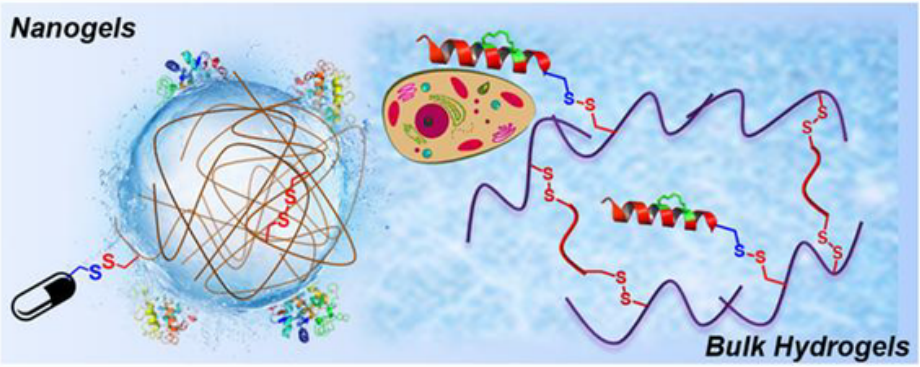


*Figure* *ations.*

**References**

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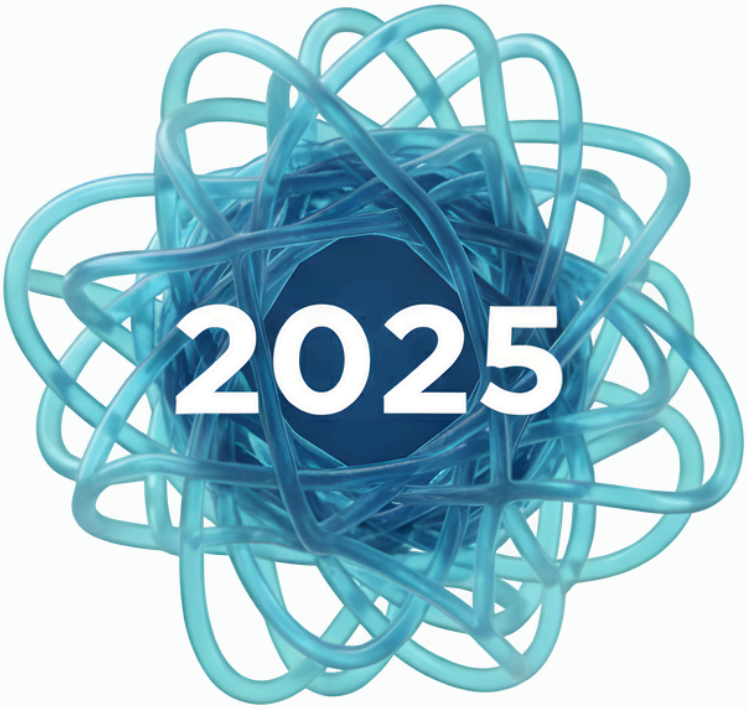


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# Poster Abstracts

# $Ca^{2+}$-Crosslinked High-Amylose Starch Beads for Intratumoral Gemcitabine Delivery: Structure, Release, and In-Vitro Performance

Hakan Avcı [1,2], Deniz Ceylan [3], Nil Azra Aytekin [3]

[1] *Istanbul University, Faculty of Pharmacy, 34093 Istanbul, Turkey*
[2] *Yildiz Technical University, Faculty of Arts and Sciences, Physics, 34220 Istanbul, Turkey*
[3] *Bezmialem Vakif University, Faculty of Pharmacy, 34093 Istanbul, Turkey*

*deniz.ceylan@bezmialem.edu.tr*

## Abstract

Pancreatic ductal adenocarcinoma (PDAC) requires localized drug-delivery systems that enhance intratumoral exposure while minimizing systemic toxicity [1]. We developed spherical high-amylose starch beads via water-based droplet gelation and $Ca^{2+}$ ionotropic crosslinking as a simple injectable depot [2]. The beads retained spherical morphology, exhibited interconnected microporosity (SEM), and showed $Ca^{2+}$-mediated interactions without new covalent bonds (FTIR). In PBS (pH 6.6, 37 °C), 10–15% $CaCl_2$ formulations remained intact but displayed α-amylase-triggered erosion over ~8–10 days. Gemcitabine was physically loaded (EE: 4.14%; ~3.53 µg/bead), quantified by HPLC-UV. Release studies showed a rapid burst followed by plateau with full mass recovery under sink conditions. Preliminary PANC-1 assays supported functional delivery. Overall, $Ca^{2+}$-crosslinked starch beads represent a solvent-free, in-vitro-tolerable platform for intratumoral chemotherapy, though improvements in loading and early release kinetics are needed.

***Keywords:*** *Pancreatic Cancer, Treatment, Starch, Calcium, Hydrogel, Sphere, Intratumoral*

## References

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**Siklodekstrin ile Çapraz Bağlı Kendi Kendini İyileştiren Supramoleküler Hidrojeller**

Şeyma Nur KİRMİÇ COŞGUN [1], Deniz CEYLAN [2]

[1] *Department of Biotechnology, Institute of Health Sciences, Bezmialem Vakif University, Istanbul, Turkey*
[2] *Department of Pharmaceutical Biotechnology, Faculty of Pharmacy, Bezmialem Vakif University, Turkey*

*skirmic@hotmail.com*

**Abstract**

Kesik koni benzeri yapılar olarak tasvir edilen siklodekstrinler (CD), polar bir dış yüzeye ve nispeten polar olmayan bir iç boşluğa sahiptir. Bu benzersiz yapı, çeşitli düşük molekül ağırlıklı bileşiklerin yanı sıra polimer zincirleriyle inklüzyon kompleksleri oluşturmalarına olanak tanır. Poli(etilen glikol) (PEG) ve α-CD bazlı inklüzyon kompleksasyonu ile supramoleküler bileşimler elde edilmesi ilk olarak 1990 yılında Harada ve arkadaşları tarafından bildirilmiştir [1]. CD bazlı supramoleküler jeller, CD'nin iç boşluğu ile polimerin enine kesit alanı arasındaki boyut uyumuna ilişkin çeşitli kovalent olmayan etkileşimler yoluyla oluşturulmuştur. Bu komplekslere, CD moleküllerinin suya daldırıldığında polimer zincirinden yeniden geçirilebildiği psödopolirotaksan (PPR) adı verilir. PPR sistemlerine dayalı CD jelleri, belirli koşullar altında CD'lerin polimer zincirlerinden ayrılmasıyla oluşan sol-jel dönüşümü nedeniyle genellikle zayıf bir stabiliteye sahiptir. Bu çalışmada, CD molekülleri, PEG ve poli(N-vinilpirolidon) (PVP) zincirlerini fiziksel bir ağ yapısı içinde tutan çapraz bağlama alanları olarak kullanılmıştır [2]. Literatür çalışmalarından farklı olarak, PVP'nin varlığı ve dolayısıyla ek ikincil kuvvetler, fiziksel olarak çapraz bağlanmış CD/PVP/PEG ağlarındaki etkileşimleri güçlendirmiştir. CD ve PEG arasındaki inklüzyon komplekslerinin oluşumu sırasında ve daha sonra yapıyı destekleyen PVP varlığında komplekslerin kendi kendine birleşmesinde yalnızca fiziksel etkileşimler sorumludur. PEG zincirlerinin moleküler ağırlığı, reaksiyon bileşenlerinin besleme oranları ve CD birimlerinin boyutunun, son ağların özelliklerini belirlemek ve kendi kendini iyileştirme yeteneğine sahip çözünmeyen ağlar elde etmek için önemli olduğu bulunmuştur. Sisteme poli(etilen glikol) dimetakrilat (PEGDMA) eklenerek fiziksel ve kimyasal çapraz bağlamanın sinerjik etkisi de değişen konsantrasyonlarda incelenmiştir.

***Anahtar Kelimeler:*** *Hidrojel, Siklodekstrin, Poli(Etilen Glikol), Kendi Kendini Iyileştirme Yeteneği*

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## Design Of Next-Generation Hydrogels For 3D Cell Culture And Tissue-Mimetic Environments

Alime SARIKAYA [1,2], Deniz CEYLAN [3], Aslıhan ARGUN [4]

[1] *Bezmialem Vakıf University, Instıtute of Health Sciences, Istanbul, Turkey*
[2] *Bezmialem Vakıf University, Experimental Application and Research Center, Istanbul, Turkey*
[3] *Bezmialem Vakıf University, Faculty of Pharmacy, Istanbul, Turkey*
[4] *Koç University, Research Center for Translational Medicine, Istanbul, Turkey*

*alimesarikaya@gmail.co; deniz.ceylan@bezmialem.edu.tr; AARGUN@ku.edu.tr*

### Abstract

Three-dimensional (3D) in vitro culture systems are gaining increasing interest as biomimetic alternatives to traditional monolayer models. Hydrogels provide an ideal microenvironment for cell growth and organization thanks to their biocompatibility, biodegradability, high water content, and tunable mechanical and biochemical properties [1, 2].
In this study, a novel emulsion system was developed to support gentle and homogeneous spheroid formation without applying mechanical stress to cells. The emulsions were composed of the most common FDA-approved polymers, and polymerization was achieved by photo-crosslinking using a suitable photoinitiator.
This system successfully achieved controlled spheroid formation within a hydrogel-like matrix, providing a biomimetic environment that mimics extracellular matrix properties and enhances cell viability. The findings suggest that water-in-water emulsions can serve as innovative, cell-friendly platforms for next-generation cell culture applications.

***Keywords:*** *Hydrogel, Emulsion, In Vitro, Polymer*

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**Microbial Exopolysaccharide-Based Gels for Emerging Biomedical Applications**

Sanem BULUT [1], Semra TASDURMAZLI [2], Tulin OZBEK [2], Esra SU [3], Kader KORKMAZ EDIS [4], Enes DERTLI [5], Mehmet Murat OZMEN [*1]

[1] *Yildiz Technical University, Faculty of Chemical and Metallurgical Engineering, Department of Bioengineering, 34220, Istanbul, Turkey*
[2] *Yildiz Technical University, Faculty of Arts and Science, Department of Molecular Biology and Genetics, 34220, Istanbul, Turkey*
[3] *Istanbul University, Faculty of Aquatic Sciences, Aquatic Biotechnology, 34134, Istanbul, Turkey*
[4] *Yildiz Technical University, Faculty of Chemical and Metallurgical Engineering, Department of Food Engineering, 34220, Istanbul, Turkey*
[5] *Istanbul Technical University, Faculty of Chemical-Metallurgical Engineering, Department of Food Engineering, 34469, Istanbul, Turkey*

**Abstract**

Exopolysaccharides offer a renewable source of biopolymers for designing soft materials with biomedical applications. Alternan, a branched exopolysaccharide produced by Lactobacillus reuteri, offers a versatile matrix for developing hydrogels and cryogels with tunable structures and properties. In this study, alternan was chemically cross-linked to form gel networks under both conventional and cryogenic conditions, allowing comparison of their structural and functional characteristics. The cryogel structures supported rapid fluid uptake and exhibited elastic recovery under mechanical stress, while incorporation of an antibacterial agent provided activity against a clinically significant pathogen. Collectively, these findings demonstrate the potential of alternan-based gels for wound-healing applications and emphasize the broader promise of exopolysaccharides as adaptable building blocks for next-generation biomaterials.

***Keywords:*** *Alternan, Antibiotic, Cryogel, Hydrogel, Wound Dressing*

**Silk Fibroin-Based 3D Printable Hydrogels as an Alternative to Silicone Breast Implants**

Selen VENEDİK [1*], Esra SU [2]

[1] *İstanbul University, Faculty of Aquatic Sciences, Su Bilimleri ve Mühendisliği Programı, Fatih, 34134, Istanbul, Turkey*
[2] *İstanbul University, Faculty of Aquatic Sciences, Department of Aquatic Biothechnology, Fatih, 34134, Istanbul, Turkey*

*esra.su@istanbul.edu.tr; selenvenedik2121@gmail.com*

**Abstract**

Breast cancer accounts for more than 25% of all cancers worldwide. Silicone breast implants are placed in breast cancer patients after the breast tissue is removed during a mastectomy. The only material approved for use by the Food and Drug Administration since 2006 is silicone elastomer or gel. This material must be removed 10-15 years after implantation due to local tissue reactions to silicone, such as granulomatous inflammation, capsular contraction, infection, and spread of silicone to regional lymph nodes following membrane rupture, gel leakage, or elastomer degradation. Therefore, there is a need to develop biocompatible and sustainable materials to replace silicone implants.
This study has produced a biopolymer-based implant that provides the properties expected of silicone implants. Production utilized both molding and 3D printing methods. Silk fibroin was used for the implant, which was produced using a combination of synthetic and biopolymer resources, to reduce the risk of reaction upon insertion and to ensure sustainability. With the biopolymer-based implant produced, it is expected that the rehabilitation period of female patients will be shortened and long-term complaints will decrease.

***Keywords:*** *Silicone, Breast Implant, Biopolymer, 3D Printing, Hydrogel*

***Acknowledgements:*** *This work was supported by the Scientific and Technical Research Council of Turkey (TUBITAK), 2209-A University Students Research Projects Support Program.*

**Synthesis and Characterization of Nanomaterials - Undergraduate Research Dielectric Characterization of pH-Responsive Hydrogels for Implantable Sensor Applications**

Elif Sümeyye Cirit [1], Metin Veysel Karagözoğlu [2], İpek Hilal Kacar [3], Volkan Can [4], Sema Dumanli [3], Fikrettin Şahin [2], Zeliha Cansu Canbek Ozdil [1]

*[1] Department of Materials Science and Nanotechnology Engineering, Yeditepe University, Istanbul 34755, Turkey*
*[2] Department of Genetics and Bioengineering, Yeditepe University, Istanbul 34755, Turkey*
*[3] Department of Electrical and Electronics Engineering, Bogazici University, Istanbul 34470, Turkey*
*[4] Department of Genetics and Bioengineering, Yeditepe University, Istanbul 34755, Turkey / Automotive Technology Program, Yeditepe University, Istanbul 34755, Turkey*

**Abstract**

Hydrogels, which are three-dimensional crosslinked polymer networks capable of absorbing large amounts of water, have gained significant attention in biomedical and sensing applications due to their biocompatibility, mechanical flexibility, and tunable dielectric behavior [1]. Their inherent pH-responsiveness makes them particularly attractive for implantable sensing systems. In this study, poly(acrylamide-co-acrylic acid) (PAAm-co-AAc) hydrogels were synthesized via free radical polymerization with varying monomer ratios to achieve tunable dielectric properties. The dielectric constant and loss factor of the hydrogels were characterized under different pH, temperature, and frequency conditions. Results showed a notable decrease in dielectric constant with increasing frequency and a distinct dependence on pH, confirming the feasibility of these materials as pH-responsive dielectric layers. The hydrogels demonstrated good dielectric stability and mechanical integrity, offering potential advantages for the design of implantable and flexible bioelectronic pH sensors [2].

***Keywords:*** *Smart Hydrogel, Dielectric Behavior, pH Sensor, Bioelectronics*

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## pH-Responsive Au/CQD-Embedded Poly(acrylic acid-co-acrylamide) Hydrogels for Ferric Ion ($Fe^{3+}$) Sensing

İzem Ezgi Sümer [1], Aleyna İşler [1], Zeliha Cansu Canbek Özdil [1], Volkan Can [2,3]

[1] *Material Science and Nanotechology Engineering, Yeditepe University*
[2] *Genetics and Bioengineering, Yeditepe University*
[3] *Vocational School, Automotive Technology Program, Yeditepe University*

### Abstract

pH-sensitive hydrogels have gained attention as smart materials capable of adapting to environmental changes. Their ability to selectively detect toxic metal ions makes them promising candidates for environmental monitoring and biosensing applications [1]. In this study, a novel pH-responsive hydrogel systems composed of poly(acrylic acid-co-acrylamide) [P(AAc-co-AAm)] and gold- carbon quantum dot hybrids (Au/CQDs) were synthesized and characterized. The acrylic acid in the polymer network impart pH sensitivity through ionization-controlled swelling, while acrylamide units provide mechanical strength and facilitate ion diffusion within the network [2]. The embedded Au/CQDs serve as fluorescent probes and metal-binding sites, enhancing the sensing performance through the metal-enhanced fluorescence (MEF) effect [3,4].
Synthesized hydrogel samples containing different nanoparticle concentrations (0%, 0.1%, 0.5%, 1.0%, 1.5%, and 2.5% v/v) were characterized via rheological analysis, pH-dependent swelling behavior, UV-Vis and fluorescence spectroscopy, and metal ion binding tests. The $Fe^{3+}$ sensing performance was examined under various pH conditions and $FeCl_3$ concentrations ranging between 20 µM - 1 mM.
This study aims to evaluate the interplay between the hydrogel's pH responsiveness and its optical behavior toward metal ions, providing a foundation for developing low- cost, portable, and efficient pH-responsive $Fe^{3+}$ sensors. The proposed hybrid material shows great potential for applications in environmental monitoring, water quality analysis, and biomedical diagnostics.

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**Design of Starch-Interpenetrated Cationic Hybrid Gel Networks: Role of Functional Groups in Tunable Swelling, Elasticity, and Dye Adsorption**

Rabia BOZBAY *, Nermin ORAKDOGEN

*Istanbul Technical University, Department of Chemistry, Soft Materials Research Laboratory, 34469, Maslak, Istanbul, Turkey*

*bozbay19@itu.edu.tr, orakdogen@itu.edu.tr*

**Abstract**

Natural polymer-integrated hybrid gel networks have recently attracted considerable scientific and industrial interest, mainly because natural polymers exhibit a wide range of desirable properties, including biocompatibility, non-toxicity, biodegradability, and structural adaptability [1]. These metarials are designed by combining natural polymers with suitably selected synthetic monomers incorporating distinct functional groups, and the synergistic interplay among these groups facilitates the development of innovative next-generation hybrid gel networks.

In this study, starch-interpenetrated cationic hybrid gel networks, PDGH/CSm, were designed by incorporating varying amounts (0–6%) of corn starch (CS) as a natural filler component into the terpolymer matrix of poly(dimethylaminoethyl methacrylate-co-glycidyl methacrylate-co-hydroxypropyl methacrylate) [P(DMAEMA-co-GMA-co-HPMA)] through free-radical (cryo)polymerization using diethylene glycol dimethacrylate (DEGDMA) as a crosslinker [2]. This study aimed to investigate the effect of the functional groups of CS, the tertiary amine groups of DMAEMA, and the epoxy groups of GMA on the resulting natural polymer-integrated hybrid gels. Furthermore, the topological optimization of the hybrid gel systems was investigated by varying the starch content, while morphological differences were evaluated through the synthesis of both hydrogels and cryogels at 8 °C (Hgel) and −18 °C (Cgel), respectively.

The structural features of the natural polymer interpenetrated hybrid gels were characterized by ATR-FTIR, XRD, DSC, TGA and SEM analyses. The mechanical properties, dynamic and equilibrium swelling behavior, and tartrazine dye adsorption performance were systematically investigated. Results demonstrated that the incorporation of an optimal amount of starch improved the mechanical, physicochemical, and functional properties of the multiresponsive hybrid network, including elasticity, swelling/deswelling behavior, and dye adsorption efficiency. This synergistic interaction contributed to the development of mechanically improved and environmentally friendly next-generation hybrid gel networks, thereby revealing their strong potential for wastewater treatment.

***Keywords:*** *Starch, Cationic Networks, Swelling, Elasticity, Adsorption, Natural Polymer-based Hybrid Gel Networks, Hydrogel, Cryogel*

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## Epoxy Functionalization Of Protein-Mediated Hybrid 2-Hydroxyethyl Methacrylate Cryogels

Mertcan ER, Nermin ORAKDOGEN

*Istanbul Technical University, Department of Chemistry, Soft Materials Research Laboratory, 34469, Maslak, Istanbul, Turkey*

*mertcaner@itu.edu.tr , orakdogen@itu.edu.tr*

**Abstract**

The presented work is concerned with the utilization of biocompatible monomer 2- hydroxyethyl methacrylate (HEMA) and functionalizable monomer glycidyl methacrylate (GMA) for in-situ preparation of protein-mediated hybrid (cryo)gels. Because of their unique biological functions, proteins are often used with synthetic polymers to create biocompatible and biodegradable hybrid systems that could be promising candidates in tissue engineering [1]. Collagen, gelatin, L-arginine and biotin were used to investigate the nature of hybrid component on the responsive swelling and the mechanical properties of copolymer P(HEMA-co-GMA) gels.
Because of their porous structure, higher swelling capacities were observed in hybrid cryogels compared to hybrid hydrogels. Collagen-containing cryogels had the highest swelling, whereas gelatin-containing cryogels showed enhanced elastic modulus. Depending on the protonation/deprotonation of -NH 2 and -COOH groups brought to the copolymeric template with the addition of proteins; all hybrid P(HEMA-co-GMA) gels showed pH-sensitive swelling. At low pH conditions, hybrid cryogels exhibited a higher swelling tendency compared to hydrogels. The degree of swelling at various NaCl and KCl salt concentrations was investigated to evaluate the ion sensitive swelling behavior. While the swelling of the hybrid networks containing gelatin and collagen decreased monotonically as the salt concentration increased, an excellent adsorption profile for methyl orange was observed for collagen-containing cryogels with a maximum removal rate of 97%, with the presence of highly reactive functional groups in the hybrid gel network. It is proposed that the prepared novel hybrid gels are suitable for a variety of technological applications ranging from biomedical applications such as drug delivery and tissue engineering to wastewater treatment.

***Keywords:*** *Cryogel, Protein, Swelling, Elasticity*

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**Optimizing Electrical Conductivity in Nanomaterial-Doped Hydrogels for Advanced Biosensing Applications**

Aleyna İşler [1], Gizem Akay Can [1], Sema Dumanli [3], Mina Namvari [2], Zeliha Cansu Canbek Özdil [1], Volkan Can [4,5]

[1] *Yeditepe University Material Science and Nanotechnology Engineering, Istanbul, Turkey*
[2] *Sabanci University Nanotechnology Research and Application Center (SUNUM), Istanbul, Turkey*
[3] *Boğaziçi University Electrical and Electronics Engineering, Istanbul, Turkey*
[4] *Yeditepe University Genetic and Bioengineering Department, Istanbul, Turkey*
[5] *Yeditepe University Automotive Technology Program*

**Abstract**

Hydrogels incorporating metal-based nanostructures have gained prominence as advanced candidates for in-body sensing technologies, owing to their distinctive combination of improved electrical performance, mechanical tunability, and biocompatibility. Among these systems, polyacrylamide-co-acrylic acid-co-polyethylene glycol diacrylate (P(AAm-co-AAc-co-PEGDA)) hydrogels integrated with silver nanowires (AgNWs) have demonstrated strong potential for continuous physiological monitoring applications [1]. Nevertheless, achieving the desired level of electrical conductivity typically requires a relatively high AgNW loading, which introduces challenges related to higher material costs and potential cytotoxic effects.
Mxenes are a new class of two-dimensional transition metal carbides and nitrides possessing high electrical tunneling due to their distinct morphology. In the present study, we investigate the integration of a trace amount of $Ti_3C_2$ Mxene into AgNW/P(AAm-co-AAc-co-PEGDA) hydrogels as an innovative strategy to further enhance electrical conductivity while reducing the required AgNW concentration. By leveraging the complementary conductive pathways provided by both AgNWs (1D) and MXene (2D) flakes, the resulting hybrid hydrogel aims to establish a more efficient and interconnected conductive network. This synergistic effect is anticipated to improve the electrical performance without compromising biocompatibility, thereby addressing key challenges associated with silver-based nanocomposites. Overall, the incorporation of $Ti_3C_2$ MXene underscores the potential of MXene-doped AgNW hydrogels as advanced materials for biomedical sensing technologies, particularly for wearable and implantable real-time monitoring systems.

***Keywords:*** *Hydrogel, Silver Nanowire, Mxene, Nanomaterial*

**References**

Elif Sumeyye Cirit, Seda Aygul Akyuz, Ahmet Bilir, Sema Dumanli, Volkan Can, and Zeliha Cansu Canbek Ozdil, ACS Applied Nano Materials 2024 7 (7), 8130-8139.

**Development of Eggshell-Loaded Starch Hydrogel Composites for Bone Tissue Engineering**

Zeynep AK [1], Burcin IZBUDAK [2], Esra SU [3], Ayca BAL OZTURK [2,4,5], Mehmet Murat OZMEN [*1]

[1] *Yildiz Technical University, Department of Bioengineering, 34220, Istanbul, Turkey*
[2] *Istinye University, Department of Stem Cell and Tissue Engineering, Institute of Health Sciences, 34010, Istanbul, Turkey*
[3] *Istanbul University, Faculty of Aquatic Sciences, Aquatic Biotechnology, 34134, Istanbul, Turkey*
[4] *Istinye University, Stem Cell and Tissue Engineering Application and Research Center (ISUKOK), 34010, Istanbul, Turkey*
[5] *Istinye University, Faculty of Pharmacy, Department of Analytical Chemistry, 34010 Istanbul, Turkey*

**Abstract**

Bone tissue engineering requires biomaterials that not only support cell growth but also stimulate osteogenesis. Starch-based hydrogels, owing to their intrinsic rigidity and environmentally friendly origin, offer a stable and sustainable matrix for scaffold development. In this study, calcium-rich waste eggshell particles were incorporated into starch hydrogels to enhance both bioactivity and mechanical performance. The combination of the rigid starch network with the mineral content of eggshells improved osteoinductive potential while strengthening the hydrogel structure, producing scaffolds capable of maintaining mechanical integrity under physiological conditions. Overall, this approach demonstrates a sustainable strategy that utilizes biowaste to generate bioactive and mechanically reinforced hydrogel tissue scaffolds with clear potential for bone regeneration.

***Acknowledgements:*** *This work has been supported by Yildiz Technical University Scientific Research Projects Coordination Unit under project number TYL-2024-6139.*

**References**

Elif Sumeyye Cirit, Seda Aygul Akyuz, Ahmet Bilir, Sema Dumanli, Volkan Can, and Zeliha Cansu Canbek Ozdil, ACS Applied Nano Materials 2024 7 (7), 8130-8139.

**Deep Eutectic Solvents And Eutectogels: Emerging Green Materials For Advanced Functional Applications**

Yahya BAŞ [1*], Yavuz Selim AŞÇI [1]

[1] *Istanbul University, Faculty of Science, Department of Chemistry, Fatih 34134, Istanbul, Turkey*

*yahyabas@istanbul.edu.tr*

**Abstract**

Deep eutectic solvents (DESs) have emerged over the past two decades as one of the most significant advancements in green and sustainable solvent chemistry. Due to their excellent solvation capabilities, facile and low-cost preparation from bio-derived components, and their "tailor solvent" nature with tunable physicochemical properties, DESs have attracted extensive attention across a wide range of polymer-related applications [1]. They have been utilized in polymer synthesis and processing through various techniques, including as reaction media in ATRP, RAFT, anionic, and polycondensation polymerizations, and even as monomeric components in polymerization systems. In addition, DESs have been applied in biomass polymer modification, functionalization of synthetic polymers, and as green solvents in emerging fabrication technologies such as 3D printing, electrospinning, and encapsulation [2]. In the field of polymeric gels, DES-based systems—known as eutectogels—have shown significant advantages. Depending on the formulation, DESs can act (1) as reaction media, (2) as a monomeric HBA or HBD component, or (3) as both [3]. The incorporation of DESs into gel matrices enhances their functionality beyond conventional hydrogels and ionic liquid gels, primarily due to their non-volatility, non-toxicity, and ease of preparation. The unique supramolecular interactions within polymer–DES systems, including ionic and hydrogen bonding between HBA/HBD species and polymer chains, contribute to improved mechanical strength, ductility, and fatigue resistance. The widespread hydrogen bonding network in eutectogels also imparts self-healing capability, while the absence or low content of water eliminates common hydrogel drawbacks such as drying or freezing [2]. Eutectogels, their tunable structure and multifunctionality enable their use in diverse advanced applications including $CO_2$ separation, drug delivery, energy storage, biocatalysis, and food packaging. Through rational formulation design, they offer enhanced gas selectivity, controlled drug release, high ionic conductivity, enzyme stabilization, and environmentally friendly packaging properties. Also, polymerizable DESs were reported for thermoresponsive hydrogels production [4]. Overall, eutectogels represent a versatile and sustainable class of soft materials with immense potential across environmental, biomedical, and industrial sectors. Their non-volatility, hydrogen-bond-driven robustness, and self-healing behavior highlight their superiority over conventional gel systems. Continued interdisciplinary efforts will be essential to fully realize the technological and ecological benefits of these next-generation eutectic-based materials.

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**Smart Cryogel Wound Dressing Applications Based on Silk Fibroin and Dimethylacrylamide**

Sera YILGÖR [1], Esra SU [2]

[1] *İstanbul University, Faculty of Aquatic Sciences, Su Bilimleri ve Mühendisliği Programı, Fatih, 34134, Istanbul, Turkey*
[2] *İstanbul University, Faculty of Aquatic Sciences, Department of Aquatic Biothechnology, Fatih, 34134, Istanbul, Turkey*

*esra.su@istanbul.edu.tr; sera.yilgor@ogr.iu.edu.tr*

**Abstract**

As the largest organ in the human body, skin serves as a fundamental protective barrier against external factors. Ensuring rapid and effective healing is crucial for wounds resulting from compromised skin integrity. Modern wound dressings are expected to maintain a moist environment and maintain oxygen permeability to support the healing process. Hydrogel-based materials are widely used for this purpose due to their high water retention capacity and ability to absorb wound exudate.
This study aimed to develop innovative and smart cryogel dressings that can provide controlled release of bioactive agents to the wound site. In this study, mechanically durable and biocompatible silk fibroin (SF) based cryogel structures were prepared for controlled drug release applications. Additionally, the creation of poly(N,N-dimethylacrylamide) (poly-DMAA)-based cryogel networks was evaluated as an alternative approach. Total porosity and pore sizes were optimized with biopolymer additives such as sodium alginate, carboxymethyl cellulose, and gum arabic. The absorption properties of the produced cryogels were characterized.
In follow-up studies, formulations demonstrating suitable properties will be subjected to further testing to establish drug loading and release profiles.

***Keywords:*** *Wound Dressing, Controlled Release, Cryogel, Smart Material*

**Multi-Responsive Nanocomposite Hydrogels for Self-Healing and Shape-Memory Wound Care Applications**

Hüsna KILIÇ [1], Deniz CEYLAN [2]

[1] *Bezmiâlem Vakif University, Health Sciences Institute, Department of Biotechnology, 34093 Istanbul, Turkey*
[2] *Bezmiâlem Vakif University, Faculty of Pharmacy, 34093 Istanbul, Turkey*

*deniz.ceylan@bezmialem.edu.tr*

**Abstract**

Smart wound-care materials that combine self-healing, shape memory, and controlled responsiveness are critical for next-generation regenerative therapies. In this study, we developed multi-responsive nanocomposite hydrogels (Nc-x) synthesized by bulk polymerization of stearyl methacrylate (SM) and vinyl pyrrolidone (VP) in the presence of gold (Au) and silver (Ag) nanoparticles.
Without using any chemical cross-linkers, the network integrity is governed by hydrophobic crystalline domains of SM and dipole–dipole interactions of VP, enabling an intrinsically dynamic and reconfigurable architecture. Incorporation of Au and Ag NPs enhanced the tunable hydrophilic–hydrophobic balance, while also contributing to light- and temperature-responsive behavior.
Nc-x gels exhibited rapid autonomous self-healing, programmable shape-memory recovery, and mechanical repair under both passive and external stimuli. In vitro studies with human dermal fibroblasts demonstrated >100% cell viability at 48 h, and scratch-wound assays revealed near-complete closure, confirming strong tissue-regenerative potential.
Overall, these nanocomposite gels represent a translational, non-invasive wound dressing platform with integrated smart functionalities, offering a promising alternative to traditional wound closure methods.

***Keywords:*** *Smart Materials, Self-Healing, Shape Memory, Stearyl Methacrylate, Vinyl Pyrrolidone, Gold Nanosphere, Silver Nanocube, Photothermal Effect, Nanocomposite*

## pH-Sensitive Magnetoplasmonic Ag@$Fe_3O_4$ Nanowire Hydrogels for Implantable Sensors

Elif Sümeyye CİRİT [1], Burak ÖZCAN [2], Volkan CAN [3], Sema DUMANLI OKTAR [2], Zeliha Cansu CANBEK ÖZDIL [1]

[1] *Department of Material Science and Nanotechnology Engineering, Yeditepe University*
[2] *Department of Electrical and Electronics Engineering, Bogazici University, Istanbul, 34470, Turkey*
[3] *Department of Genetics and Bioengineering, Yeditepe University, Istanbul, 34755, Turkey, Automotive Technology Program, Yeditepe University, Istanbul, 34755, Turkey*

**Abstract**

pH-responsive hydrogels, three-dimensional, crosslinked polymeric networks capable of absorbing large amounts of water, have gained significant attention in biomedical applications due to their high biocompatibility, water permeability, stimuli sensitivity, self-healing ability, flexibility, and soft mechanical properties [1]. Conductive pH-responsive hydrogels further combine these advantages with electrical conductivity, making them highly attractive for biosensing, bioelectronics, and soft robotics applications [2].

Here, we present magnetoplasmonic Ag@$Fe_3O_4$ core–shell nanowires incorporated into an acrylic acid/acrylamide/PEGDA hydrogel framework as a multifunctional, pH-responsive material for wireless in-body sensing. The dual functionality of these nanowires arises from their unique composition: the silver core provides strong plasmonic activity and electrical conductivity, while the $Fe_3O_4$ shell imparts magnetic responsiveness, allowing both signal generation and degradation tracking within physiological environments. Ag nanowires with diameters of approximately 72 nm and lengths near 9.5 µm are synthesized using a polyol reduction process, which ensures high uniformity and aspect ratio control [3]. These nanowires are subsequently coated with an $Fe_3O_4$ shell through an aqueous coprecipitation route, yielding Ag@$Fe_3O_4$ structures with a shell thickness of roughly 16 nm [4]. The core-shell nanowires are then embedded within the P(AAm-co-AAc-co-PEGDA) hydrogel matrix via free-radical polymerization, forming a conductive and magnetically active hybrid network. In conclusion, although the $Fe_3O_4$ magnetic coating reduces conductivity, it provides the advantage of real-time monitoring of the hydrogels through magnetic particle imaging, enabling non-invasive evaluation of their deformation within physiological environments.

***Keywords:*** *$Fe_3O_4$@Ag Core-shell Nanowires, pH-responsive Hydrogels*

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**PVA Nanogel Simulation Polyvinyl Alcohol (PVA) Nanogels: A Computational Study of Structure-Property Relationships**

Ezgi Taş [1], Kutlu Ö. Ülgen [1], Volkan Can [2], Zeliha Cansu Canbek Özdil [2]

[1] *Boğaziçi University, Istanbul, Turkey*
[2] *Yeditepe University, Istanbul, Turkey*

## Abstract

Polyvinyl alcohol (PVA) nanogels are elastic, cross-linked polymer networks widely used in drug delivery and wound dressing due to their hydrophilicity, biodegradability, and biocompatibility [1]. Optimizing their performance for specialized applications requires a deep understanding of the relationship between their molecular structure and nanoscopic properties. This study introduces a computational framework using molecular dynamics (MD) simulations to systematically investigate the eNects of molecular architecture and environmental factors on PVA nanogel properties. Our approach utilizes atomistic MD simulations, conducted using the LAMMPS package, to model borax-cross-linked PVA nanogels. Specifically, a PVA chain with 20 repeating units and 3 cross-linking points was modeled in aqueous solvents at varying pH. We simulated the eNects of environmental conditions, temperature, and pH on critical nanogel characteristics, including mechanical properties, swelling behavior, chain length, and
water diNusion. Key findings highlight how the nanogel's network architecture is significantly influenced by the dynamics of water molecules within the matrix, which enables diNusion-controlled applications like drug release. By providing molecular-level insights into the structure-property relationships of cross-linked PVA, this work enables more eNicient, mechanism-based design strategies for tailored nanogel applications in biosensing and advanced biomedicine. This computational methodology oNers a predictive tool to accelerate the development and optimization of next-generation hydrogel materials.

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# Development And Characterization Of Novel Adsorbent Material For The Removel Of Toxic Industrial Chemicals

Selinay KETEN [1,2*], Prof. Dr. Suzan ABDURRAHMANOĞLU [2], Dr. Melek EROL [3]

[1] *Marmara University, Institute of Science and Technology, Department of Polymer Science and Technology Istanbul, Turkey*
[2] *Marmara University, Faculty of Science, Department of Physical Chemistry, Istanbul, Turkey*
[3] *TÜBİTAK Marmara Research Center, Gebze, Kocaeli*

*selinayketenn@gmail.com; suzana@marmara.edu.tr; melek.erol@tubitak.gov.tr*

**Abstract**

The release of dyes used in industrial applications into wastewater poses a serious environmental problem and represents a significant threat to human health. Adsorption techniques have been employed to remove these dyes from wastewater. In this study, a bead-shaped composite adsorbent was synthesized using chitosan, an environmentally friendly biopolymer, and mordenite, a member of the zeolite family. The removal of methyl green (MG) and methyl orange (MO) from aqueous solutions was investigated.

To improve the limited chain flexibility and low mechanical strength of chitosan, a cross-linking strategy combined with zeolite incorporation was adopted to create a composite structure. Although chitosan-based adsorbents are effective in removing anionic dyes, their performance against cationic dyes is limited due to their similar charge. [1] For this reason, the composite beads synthesized in this study were structurally designed to adsorb both anionic and cationic dyes.

The conditions required for forming the composite beads were investigated, and parameters such as chitosan concentration, zeolite content, and cross-linker concentration were examined to achieve the final formulations. [2] [3] In the adsorption studies, the effects of pH, dye concentration, adsorbent dosage, and contact time were evaluated. Under optimal conditions, removal efficiencies of 93.47% for MO and 85.95% for MG were obtained. Figure 1 provides a schematic summary of the synthesis of the chitosan–mordenite composite bead and the adsorption process of MO and MG dyes.

The structural, thermal, and physical properties of the composites were characterized using FTIR, SEM, TGA, and BET analyses. The amount of dye adsorbed during the experiments was measured using a UV–VIS spectrophotometer, and adsorption capacities were calculated from the obtained results. [4] The reusability of the composite adsorbent was also examined through desorption studies, and it was observed that—after five cycles with NaOH solution—the removal performance remained at 81% for MO and 77% for MG.

**Keywords:** *Chitosan, Mordenite, Composite Beads, Adsorbance Capacity*

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**Removal Of Phosphate From Aqueous Solution By Chitosan-Alginate Hydrogel Beads**

Farid Sattarpour [*1], Prof. Dr. H. Ozan Gulcan [†2], Prof. Dr. Mustafa Gazi [‡1]

[1] *Department of Chemistry, Eastern Mediterranean University, Gazimagusa, TRNC via Mersin 10, Turkey*
[2] *Faculty of Pharmacy, Eastern Mediterranean University, Gazimagusa, TRNC via Mersin 10, Turkey*

⁎ *Corresponding Author Farid.Sattarpour@emu.edu.tr; †Ozan.gulcan@emu.edu.tr; ‡Mustafa.gazi@emu.edu.tr*

**Abstract**

Phosphorous is an effective and essential mineral nutrient for the growth of biological creatures and it is very necessary for functioning of ecosys- tems normally. However, the increase in the usage of phosphorous in lots of parts including industry, agricultural and municipalities causes to pollution of water bodies. Additionally, consumption of water which is rich in content of phosphorous can cause to decrease in the levels of calcium amount of blood and that can result in osteoporosis, hyperphosphatemia and hazard public health. For protection of human health and aquatic ecosystems, the amount of phosphorous should be controlled within the limits (¡0.5 mg/L as it has been reported by World health organization).
The removal of phosphorous from water bodies relies mostly on the adsorbents usage which are effective. In this study, chitosan-alginate hydrogel beads were prepared by mixing chitosan and sodium alginate solution together and dropping them into calcium chloride solution. Sodium alginate and chitosan mixture causing interpenetrated network improves the resistance of the beads in acidic mediums. For characterization of beads SEM and FTIR analysis were conducted to prove the presence of functional groups and calcium ions which has the main effect in phosphate adsorption. Additionally, UV spectroscopy method was used to study adsorption capacity which illustrated that with increasing adsorbent concentration and time, the amount of adsorbed phosphate increase considerably.

# Hybrid Cryogels Containing Liposomal Structures

T.S.Yıldırım [1*], D. Ceylan [2]

[1] *Department of Biotechnology, Institute of Health Sciences, Bezmialem Vakif University, Istanbul, Turkey,*
[2] *Department of Pharmaceutical Biotechnology, Faculty of Pharmacy, Bezmialem Vakif University, Turkey*

*seraytuana@hotmail.com*

## Abstract

Cryogels constitute a class of biomaterials with potential properties over conventional hydrogels due to their macroporous structure and highly hydrated core, mimicking the composition of extracellular matrix cartilage [1]. As drug carriers, liposomes have targeted delivery, high biocompatibility, biodegradability, easy functionalization, low toxicity and immunogenicity, thus the presence of these features greatly enhances the sustained release and therapeutic index of drugs. Trough to this system, it will be possible to reduce the side effects of drugs and increase the effectiveness of treatment. In this study, cationic liposome structures will be incorporated into alginate-based cryogel spheres and their potential to carry therapeutic agents will be examined. As the hydrophobic tail quickly moves away from the oil in a water-based solution, phospholipids spontaneously line up in two parallel layers, forming spherical liposome structures. Liposomes are unique phospholipid spheres developed to ensure maximum reach of active ingredients to target tissues and cells. With liposomal technology, the active ingredients are protected against factors that neutralize them in the digestive system and blood, thus increasing their bioavailability and intracellular uptake. Within the scope of the study, cryogels were obtained using alginate-coated cationic liposomes. Cryogels prepared below the freezing point of the solvent have superior mechanical properties through to their interconnected pore structure and thick pore walls, and respond quickly to external stimuli [2]. The interconnected macroporous structure in cryogels will facilitate cell infiltration and traffic. It is planned to include liposomal systems in the structure so that the active ingredients reach the target tissues and cells at the maximum level thanks to phospholipid beads.
There are only two articles in the literature of incorporating liposomal systems into the cryogel structure, and the polymer structures and liposomal systems to be used in this project are different. The high water retention capacity, high oxygen permeability and cell proliferation of cryogel are promising for the system we will create with liposomes. Due to their amphiphilic properties, lipophilic drugs can be trapped in phospholipid bilayers or adsorbed on the liposome surface, while hydrophilic drugs can be encapsulated by the aqueous interior of the vesicles. Liposomes; small molecule drugs, peptides, proteins nucleic acids, etc. Significant progress has been made in transportation in recent years. As drug carriers, liposomes provide sustained release of drugs due to their properties such as targeted delivery, high biocompatibility, biodegradability, easy functionalization, low toxicity and immunogenicity, while greatly increasing their therapeutic index. Due to these properties, liposomes constitute a suitable delivery system to achieve the optimal therapeutic effect.

***Keywords:*** *Cryogels, Liposomes, Phospholipids, Alginate, Drug Delivery Systems*

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**Design and Characterization of pH-Responsive Hydrogels for Delivering Trehalose –Au Nanoparticles as Protein Aggregation Inhibitors**

P. Karacan [1], D. Ceylan [2], S. Abdurrahmanoğlu [1]

[1] *Marmara University, Faculty of Science, Istanbul, Turkey*
[2] *Bezmialem Vakif University, Faculty of Pharmacy, Istanbul, Turkey*

*karacanpinar@gmail.com; suzana@marmara.edu.tr; deniz.ceylan@bezmialem.edu.tr*

**Abstract**

Trehalose is a non-reducing disaccharide that has recently gained prominence as an inhibitor of protein aggregation. This sugar can be chemically functionalized with various groups, and both its analogues and their combinations with gold nanoparticles (AuNPs) have been explored in neurodegenerative disease research for their potential protective effects, including extended lifespan [1]. We synthesized a trehalose- and lipoic acid-functionalized gold nanoparticle (Au@Lip-Tre) with a 10–20 nm Au core. The goal of this study was to evaluate the ability of pH-responsive hydrogels to release these nanoparticles within gut-like environments, motivated by their potential relevance to gut–brain signalling. Hydrogels were chosen as the delivery matrix due to their suitability for controlled drug release and their responsiveness to environmental stimuli such as pH [2]. In this study, a series of pH-sensitive hydrogels were synthesized using sodium alginate (Alg), acrylic acid (AAc) as monomers, and ethylene glycol dimethacrylate (EGDMA) or tetraethylene glycol dimethacrylate (TEGDMA) as cross-linkers. These hydrogels were characterized to assess their pH-responsive swelling behavior and their ability to release Au@Lip-Tre nanoparticles under different pH conditions simulating physiological environments. Formulation-dependent differences showed that both crosslinker type and alginate incorporation significantly influenced mechanical properties and swelling behavior. The gold nanoparticles exhibited approximately 50% release from the hydrogel system. Overall, the results demonstrate that polymer composition and crosslinking density can be strategically tuned to modulate nanoparticle release profiles, highlighting the potential of these hydrogels for gut-targeted delivery of trehalose-functionalized AuNPs.

***Keywords:*** *Trehalose, Gold Nanoparticle, Hydrogel*

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**Synergetic Effect Of The Size Of Crosslinker And Polysaccharides On The Network Structure Of Acrylamide Hydrogels**

Ferda Gonulkirmaz [1], Selinay Keten [1], Pinar Karacan [1], Deniz Ceylan [2], Suzan Abdurrahmanoğlu [*1]

[1] *Deparment of Chemistry, Faculty of Arts and Science Marmara University 34722 Istanbul, Turkey*
[2] *Faculty of Pharmacy, Bezmialem Vakıf University Istanbul, Turkey*

*suzana@marmara.edu.tr*

**Abstract**

Polysaccharides are widely used to synthesis hydrogels especially in the area of biomaterials due to their biocompatibility and abundancy in nature. In the case biomaterials, the homogeneity of the network structure of the hydrogel is also important by means of uniformity of the properties (elasticity, swelling, pore structure etc.) throughout the materials. In our previous study, we synthesized dextran-acrylamide hydrogels in a single step reaction and observed the increasing flexibility of the acrylamide hydrogels networks by the addition of dextran as expected [1]. We had also showed that the homogeneity of the network could be improve by the increasing size of the crosslinker by Okay group [2]. Combining these two studies we aim to synthesize hydrogel with highly elastic and homogeneous network structure in a single step reaction which could be used as biomaterials such as wound dressing. Besides the hydrogels obtained from this study could be used as a model for the future hydrogels based on the polysaccharides and biocompatible synthetic monomers.
In this study the acrylamide hydrogels were synthesized using tetraethylene glycol dimethacarylate (TEGDMA) as crosslinker which relatively longer than N, N'-methylenebisacrylamide (MBA). Dextran, starch and sodium alginate were used as polysaccharide to add the network structure. The synthesis of acrylamide hydrogels was carried out at 60oC using ACVA as thermal initiator. The method used in the synthesis was used first in our previous study [1] to provide the gelation of dextran in a single step reaction. All the sample were characterized by means of swelling, mechanical and rheological properties.
All the results were presented in comparison with those of the conventional acrylamide hydrogels. In conclusion all type of polysaccharide addition and also crosslinker increased the elasticity of the network structure by means of modulus and also the swelling amounts of the acrylamide hydrogels. We have also compared the effect of the each polysachharides and found that the alginate has more effective to improve the properties of network structure. Therefore, the results are very promising for our future studies that already planned to obtain well designed biomaterials.

***Keywords:*** *Network, Homogeneity, Polysaccharides, Hydrogel*

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