Environmentally friendly hydrogels for medical and pharmaceutical applications

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The Polymer group of the Faculty of Technology and Metallurgy University of Belgrade deals with environment-sensitive hydrogel as carriers for biomedical applications, including drug delivery, wound healing, and regenerative medicine. The first hydrogel generation synthesized in our labs was discs made of polyacrylamide and its derivatives. The synthesis was at higher temperatures (50 °C), with traditional crosslinker, N, N'-methylenebisacrylamide, and persulphate/pyrosulphate as initiator.

Due to the growing demands for environmental sustainability, the general approach changed to reduce petrochemical raw materials and prepare eco-friendly materials focusing on 1) renewable polymers, initiators, and crosslinkers and 2) the application of simple, cost-effective, and eco-friendly approaches in hydrogel synthesis.

To obtain the second hydrogel generation, we use renewable polymers: polysaccharides, proteins, and polyhydroxyalkanoates [1]. Still, the mechanical strength was weak. Hence, the application of carboxylic acids, methacrylic and itaconic, and N-isopropyl acrylamide improves mechanical properties and enhances the environmental stimuli of the carriers. Instead of traditional crosslinkers - organic molecules, we gave the advantage to plant extracts like genipin, sodium tripolyphosphate, citric acid, and calcium chloride. We made beads, microgels, aerogels, discs, films, and cylinders sensitive to pH, temperature, magnetic field, or specific molecules such as glucose. Facing an everyday challenge, improving drug delivery routes, especially for poorly water-soluble drugs, and finding an alternative to traditional antibiotics, encapsulation, and controlled release remain a challenge. Therefore, we used a mild condition (e.g., deep coating) to encapsulate/release traditional water-soluble and poorly water-soluble drugs, proteins, phenolic compounds, or supercritical carbon dioxide ($scCO_2$) for thymol, carvacrol, and eugenol, a promising alternative for traditional antibiotics [2]. Furthermore, we reduced the hydrogel production temperature to ambient conditions and made a simple and cost-effective production process that doesn't require special equipment.

The promising results we got pushed us further. So, the current research focuses on the encapsulation/controlled release of antioxidant phenolic compounds extracted from orange peel waste by applying ultrasonic-assisted extraction and deep eutectic solvent (DES) based on glycerol: urea: water. We use a new initiator system based on vitamin C and H_2O_2 to polymerize a methacrylic acid [3] that could be useful for other monomers. As a concluding remark, we achieved significant progress in hydrogels encouraging us to continue further.

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