Interpenetrating polymer network hydrogels using natural based dyes initiating systems: Antibacterial activity and 3D/4D performance

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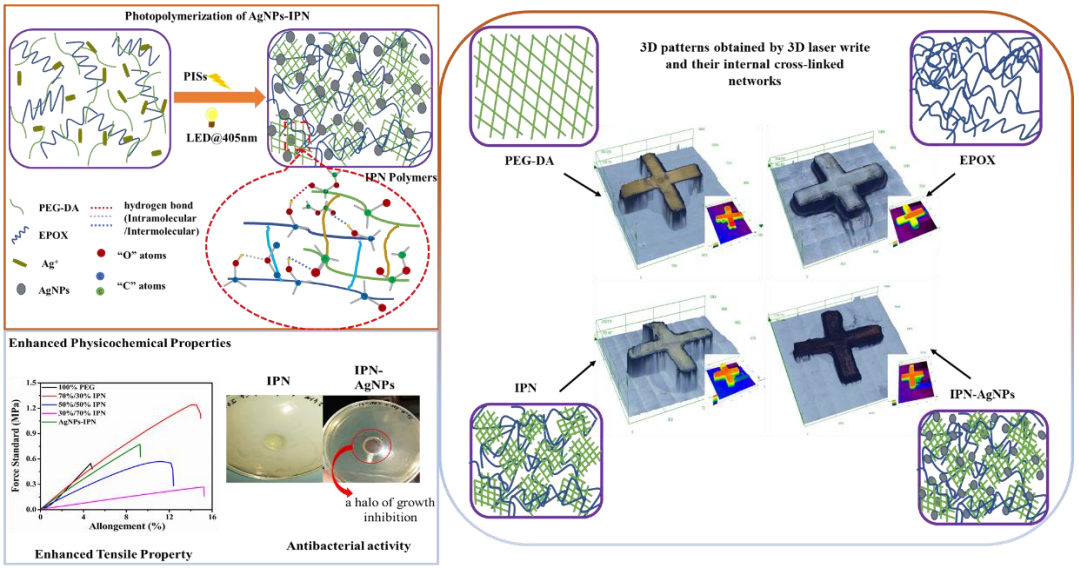
ABSTRACT:

In the past few decades, interpenetrating polymer network (IPN) hydrogels have attracted huge attention due to their special cell-like structures, interpenetrating interface, and two-phase continuity, which has special synergistic effects on their performance and function [1-2]. In this work, eleven different dyes based on 1-aryl-3-(2,4,5-trimethoxyphenyl)prop-2-en-1-one or 3-aryl-1-(3,4,5-trimethoxyphenyl)prop-2-en-1-one were firstly synthesized, and combined with an amine (i.e. ethyl l,4-(dimethylamino)benzoate, EDB) and an iodonium salt (bis(4-tert-butyl phenyl) iodonium hexafluorophosphate, Iod) as the three-component photoinitiating systems (PISs) to induce both the free radical photopolymerization (FRP) of polyethylene glycol diacrylate (PEG-DA) and the cationic photopolymerization (CP) of 3,4-epoxycyclohexylmethyl-3',4'-epoxy-cyclohexane carboxylate (EPOX) under the irradiation of LED@405nm. The best candidates were selected from the proposed eleven different dyes to study the relevant oxidation-reduction reaction mechanisms through various techniques. The best candidates were also used to prepare PEG-DA/EPOX interpenetrating polymer networks (IPNs). More interestingly, stable 3D patterns were successfully produced through direct laser write (DLW) technology, meanwhile, the silver cations could also be reduced in situ into silver nanoparticles. Furthermore, 4D printing could be achieved since all the obtained 3D patterns exhibited reversible swelling properties and the shape-memory effect caused by swelling and dehydration processes. Parallel to this, the influence of AgNPs on the mechanical properties of the 3D-printed objects and on IPNs was also systematically studied. Finally, the obtained IPN polymers containing silver nanoparticles (AgNPs) exhibited antibacterial activities for Gram-positive bacteria (e.g. Staphylococcus aureus) and Gram-negative bacteria (e.g. Pseudomonas aeruginosa).

Figure 1 : The photopolymerization of AgNPs contained IPN polymers and their antibacterial activity and 3D application.



References

1- Hasan, M.; Habib, L.; Anwaruzzaman, Md.; Kamruzzaman, Md.; Nuruzzaman Khan, N.; Rahman, M.M. Chapter 3: Processing Techniques of Chitosan-Based Interpenetrating Polymer Networks, Gels, Blends, Composites and Nanocomposites. Editor(s): Gopi, S.; Thomas, S.; Pius, A. Handbook of Chitin and Chitosan, Elsevier, 2020: 61-93.

2- Sundaram, B.M.; Mendez, R.B.; Auad, M.L.; Tippur, H.V. Quasi-Static and Dynamic Mechanical Behavior of Transparent Graft-Interpenetrating Polymer Networks (Graft-IPNs). Polym. Test. 2018： 348-362.