Technology Offer

TT-Ref. 2016-173

Empa
Materials Science and Technology

Phosphine-oxide based functional polymers for pH and solvent responsive organogels and hydrogels

Invention

A novel class of phosphorous-based linear and cross-linked functional polymers has been synthesized that form hydrogels and organogels. The facile synthesis, performed under mild conditions, uses the Michael addition reaction of phosphine oxide and nucleophiles of variable carbon chain length without catalysts and cross linkers. Such highly transparent gels can be fine-tuned to display a variety of properties, e.g. pH responsiveness, flame retardancy, biocompatibility.

Background

Recently, water-insoluble and water-swellable gels are attracting an increasing interest in a wide range of biomedical applications such as carriers for delivery of various drugs, peptides, and proteins. Their reversible swelling ability enables them to modulate the release behavior according to the external stimuli such as pH, temperature, ionic strength, electric field, or specific analyte concentration gradients.

A number of methods have been developed for preparation such gels, e.g. radical initiation generated via thermal energy, or the photo-cleavage of initiator molecules, and "Click" chemistry, but the applications of above methods are limited because of the toxicity of used catalysts or initiator and the complicated chemical synthesis, which poses a significant challenge.

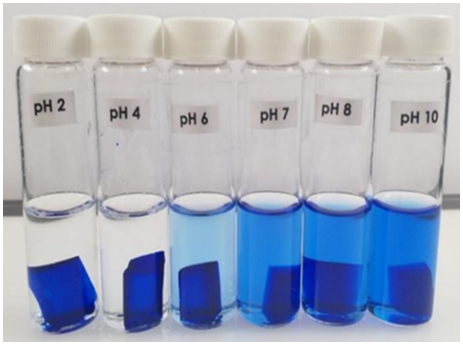
Advantages

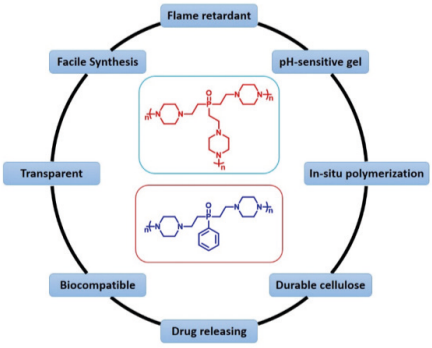
The challenges described above have been solved by using reactive organophosphorus compounds containing unsaturated vinyl bonds to develop macromolecular derivatives via radical reactions or Michael addition with suitable nucleophiles. Further advantages are absence of catalysts and initiators, low temperature synthesis, no need of post-purification, in-situ-polymerization, no side-reactions and unreacted monomers.

Applications

Range of achievable properties of the gels: inherently flame retardant, biocompatible, hydrogels, organogels, pH-sensitive (see Figure), salt-sensitive, transparent, swelling/de-swelling, non-toxic.

Applications: responsive materials for sensors, solid supports for catalysis, cationic polymers for metal chelation, adhesion promotion, flame-retardant materials, drug delivery/release, pharmaceutical as carriers for various drugs, peptides, and proteins. Gel-metal nanocomposites can be prepared for use in catalysis or wound protection/healing, durable cellulose.





Ownership

Empa, Swiss Federal Laboratories for Materials Testing and Research, Überlandstrasse 129, CH-8600 Dübendorf; Patent pending

References

1. Nazir, R.; Parida, D.; Guex, A. G.; Rentsch, D.; Zarei, A.; Gooneie, A.; Salmeia, K. A.; Yar, K. M.; Alihosseini, F.; Sadeghpour, A.; Gaan, S., Structurally Tunable pH-responsive Phosphine Oxide Based Gels by Facile Synthesis Strategy. ACS Applied Materials & Interfaces 2020, 12 (6), 7639−7649.
2. Gaan, S.; Hufenus, R.; Nazir, R.; Simonetti, P.; Salmeia, K.; Parida, D.; Gooneie, A. Phosphorus-containing oligomers and polymers. WO2019219977A1, 2019.
3. Simonetti, P.; Nazir, R.; Gooneie, A.; Lehner, S.; Jovic, M.; Salmeia, K. A.; Hufenus, R.; Rippl, A.; Kaiser, J.-P.; Hirsch, C.; Rubi, B.; Gaan, S., Michael addition in reactive extrusion: A facile sustainable route to developing phosphorus based flame retardant materials. Composites Part B: Engineering 2019, 178, 107470.

Keywords

phosphine oxide, functional polymer, hydrogel, organogel, halogen free, non-toxic, flame-retardancy, polyamide 6, durable cellulose, michael addition, drug delivery, biocompatibility, antimicrobial cellulose, transparent, swelling, pH-sensitive, salt-sensitive

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