



Chitosan and mixtures with aqueous biocompatible temperature sensitive polymer as flocculants

Simona Schwarz^{a,*}, Sandra Montserrat Ponce-Vargas^b, Angel Licea-Claverie^b, Christine Steinbach^a

^a Leibniz-Institut für Polymerforschung Dresden e.V., Hohe Strasse 6, D-01069 Dresden, Germany

^b Instituto Tecnológico de Tijuana, Centro de Graduados e Investigación, A.P. 1166, 22000 Tijuana, BC, Mexico

ARTICLE INFO

Article history:

Received 3 November 2011

Received in revised form 16 March 2012

Accepted 19 March 2012

Available online 28 March 2012

Keywords:

Chitosan

Temperature sensitive polymers

Flocculation

Clay

ABSTRACT

A novel strategy for faster and better flocculation in solid–liquid separation processes is reported: the use of a natural polyelectrolyte (chitosan) in combination with a biocompatible thermosensitive polymer [poly(*N*-vinylcaprolactam) (PNVCL)].

Clay dispersions were used as model and evaluated by means of analytical centrifuge, laser diffraction, streaming potential and turbidimetry studies.

Results show that at 45 °C the density of the sediment is up to 15% higher, as compared to the use of chitosan only. This results from the temperature sensitive behaviour of PNVCL that phase separate expelling water at temperatures higher than its LCST (32–34 °C).

By using this strategy the sediment is more compact, contains less water, and contains a very small amount of biodegradable chitosan and biocompatible PNVCL.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

Solid–liquid separation through coagulation and flocculation is an important stage of many technological processes. Typical examples are waste water treatment, sludge dewatering, pulp and paper production as well as the pharmaceutical, cosmetic and metal working industry. The overwhelming majority of these processes use polyelectrolytes to regulate the stability and flocculation properties of dispersed systems. This resulted in a great variety of synthetic and natural flocculants, which are now commercially available to meet the specific demands of industrial fields, where an efficient solid–liquid separation is required [1–14].

In this work a novel strategy for a faster and better flocculation performance was investigated: the use of natural polyelectrolytes like chitosan in combination with a biocompatible polymer showing a lower critical solution temperature (LCST) in water. By this strategy we envision to speed up the flocculation process and to decrease the water content of the sediment by taking advantage of the change from hydrophilic to hydrophobic of a LCST polymer by heating.

Normally the solubility of compounds in a good solvent is increased by increasing the temperature, an example is sugar in water. However for polymer solutions the solubility depends on

specific interactions between the polymer chain with the solvent but also on interactions within the polymer chain itself. Often, there is a limit in concentration for the solution of a polymer in a given solvent and if an increase in temperature worsens the solubility leading to phase separation, we talk about the *lower critical solution temperature* (LCST), of the system. Poly(*N*-isopropylacrylamide) (PNIPAAm) is the most studied polymer showing a LCST behaviour in water [15–19]. By heating an aqueous solution of PNIPAAm it can be observed that at temperatures around 32 °C, the solution becomes turbid, followed by the formation of flocks that finally precipitate.

How do a temperature sensitive polymer influences the aggregation process of a dispersion in presence of another flocculant? Although since 1985 a Patent describes the use of temperature sensitive flocculation [20], currently there are only scarce literature reports in this specific area of research. For example Deng et al. describes that a colloidal TiO₂ suspension form flocks with a particle diameter of 266 nm using a cationic modified NIPAAm copolymer containing 2.2 mol% of diallyldimethylammonium chloride. A faster and broader flocculation was reported to occur at 42 °C as compared with 23 °C. The authors explain that at 42 °C cationic colloidal particles with a diameter of 87 nm are formed that works as flocculants [21]. In other report, Sakohara et al. use both cationic and anionic modified PNIPAAm copolymers for the flocculation of TiO₂ [22–24]. They introduce a new concept of flocculation/compaction, explaining that after flocculation the flocks are compacted by dewatering taking advantage from the change from hydrophilic to hydrophobic of the PNIPAAm chains by heating.

* Corresponding author. Tel.: +49 351 4658333; fax: +49 351 4658231.

E-mail address: simsch@ipfdd.de (S. Schwarz).