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Phenols removal from wastewaters using (*N*-succinyl)grafted chitosan

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A modified chitosan derivative was synthesized from succinic anhydride (SA) in order to remove *p*-nitrophenol (p-NP) and *p*-chlorophenol (p-CP) from synthetic wastewaters. Chitosan has been proved to present extremely high adsorption capacity (Q) in various environmental pollutants as dyes, heavy metals, pharmaceutical compounds etc. In the present study, another type of pollutants as phenols was investigated. Phenols are persistent pollutants and show great damage to environment. They have been designated as priority pollutants by the US Environmental Protection Agency. Therefore, recently, interest has been focused on the removal of phenols from aqueous solution. In order to remove phenols from effluents, (*N*-succynil)grafted chitosan (denoted as NSCS) as adsorbent material was prepared. This was evaluated to sufficiently remove both p-NP and p-CP from aqueous solutions. After complete characterization study with FTIR, SEM and BET analysis, the evaluation of adsorption was done with experiments at pH range 2-12 and then varying the initial concentrations of phenols. Langmuir and Freundlich equations were used to fit the adsorption data and showed maximum adsorption capacities 174 mg/g at 25 °C for p-CP and 129 mg/g for p-NP. The effect of temperature showed the decrease of adsorption capacity for both phenols at increased temperature (from 25 to 65 °C). Pseudo-first, -second and intraparticle diffusion models were tested to fit the experimental kinetic data. Furthermore, the salinity (ionic strength) effect was also tested, in line with the reuse potential of the materials in sequential adsorption-desorption cycles.

Keywords: chitosan, phenols, adsorption, N-succinyl, wastewaters

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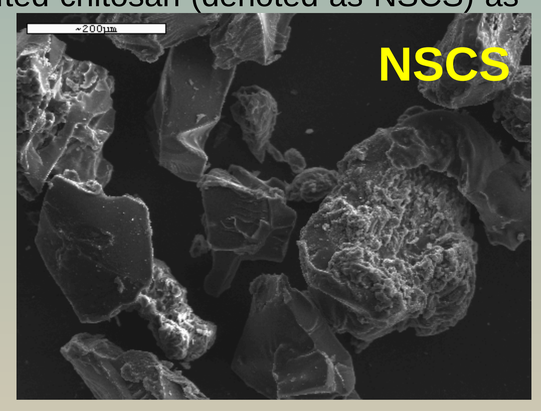
Aim/Scope

A modified chitosan derivative was synthesized from succinic anhydride (SA) in order to remove p-nitrophenol (p-NP) and p-chlorophenol (p-CP) from synthetic wastewaters. Chitosan has been proved to present extremely high adsorption capacity (Q) in various environmental pollutants as dyes, heavy metals, pharmaceutical compounds etc. In the present study, another type of pollutants as phenols was investigated. Phenols are persistent pollutants and show great damage to environment. Therefore, recently, interest has been focused on the removal of phenols from aqueous solution. In order to remove phenols from effluents, (N-succynil)grafted chitosan (denoted as NSCS) as adsorbent material was prepared. This was evaluated to sufficiently remove both p-NP and p-CP from aqueous solutions.



Synthesis

1 g of chitosan was dissolved in 200 mL of 1 wt.% aqueous acetic acid solution. 0.2 succinic anhydride (SA) was dissolved in acetone (20 mL) and the solution was added to the chitosan solution prepared above over a period of 30 min at 30 °C. Then the reaction was allowed to continue at 35 °C for 4 h. The reaction product was precipitated by adding an excessive amount of acetone, filtered to remove the solvent and then washed with 30:70, 20:80, and 0:100 water:acetone mixture sequentially. Finally, the product was dried at 35 °C under vacuum for 24 h to obtain 1.1 g of NSCS as white powder.

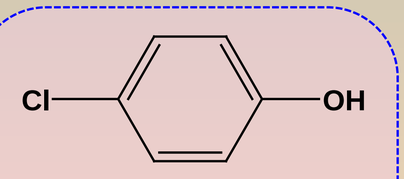
Experimental

The influence of pH on dye adsorption was studied by mixing 0.05 g of NCSC with 50 mL of an aqueous phenol solution (C_0=100 mg/L). Immediately after mixing, the suspension was allowed to adsorb phenols by shaking for 24 h (contact time). The temperature was maintained constant at 25 °C using thermostatically controlled water bath (Julabo SW-21C). The pH value, ranging between 2 and 12, was kept constant throughout the whole adsorption process with micro-additions of 0.1 M HNO_3 or 0.1 M NaOH. Similarly, the effect of pH on desorption of the adsorbed phenol from NSCS was studied in a batch experimental set-up. After adsorption (at the optimum pH found), the samples were collected and filtered using 0.45 μm pore-sized membranes. A small fraction of the phenol (~1-2 %) and the adsorbent (~1%) were retained on the filter membrane; these small variations due to filtration were neglected. Desorption experiments were performed by mixing the collected amount of phenol-loaded NSCS with aqueous solutions over a pH range of 2-12. After 24 h of shaking at 25 °C, the samples were collected and analysed for determination of the optimum desorption pH.

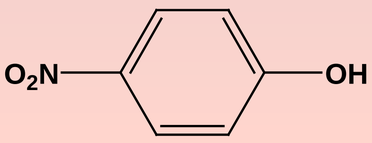
Batch kinetic experiments were performed by mixing a fixed amount of NSCS (0.05 g) with 50 mL of an aqueous phenol solution (100 mg/L). The suspensions were shaken for 24 h at pH=2 (optimum adsorption pH value found from the pH-effect experiments) in water bath at 25 °C. Samples were collected at fixed intervals (5 min - 24 h) and analyzed using a UV-Vis spectrophotometer.

The effect of initial phenol concentration was determined by contacting 0.05 g of NSCS with 50 mL of aqueous phenol solutions (C_0=10-200 mg/L). Immediately after mixing, the suspension was allowed to rebind dyes by shaking for 24 h (at pH=2, determined as optimum value) at 25 °C.

Phenols

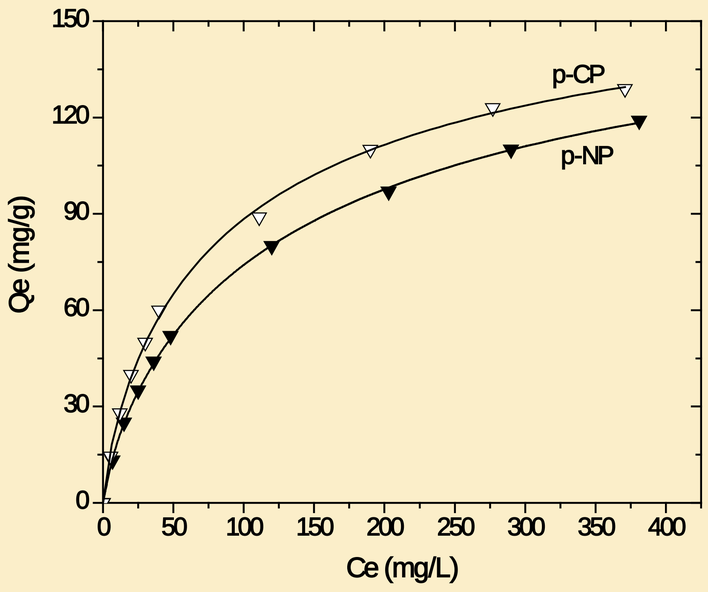


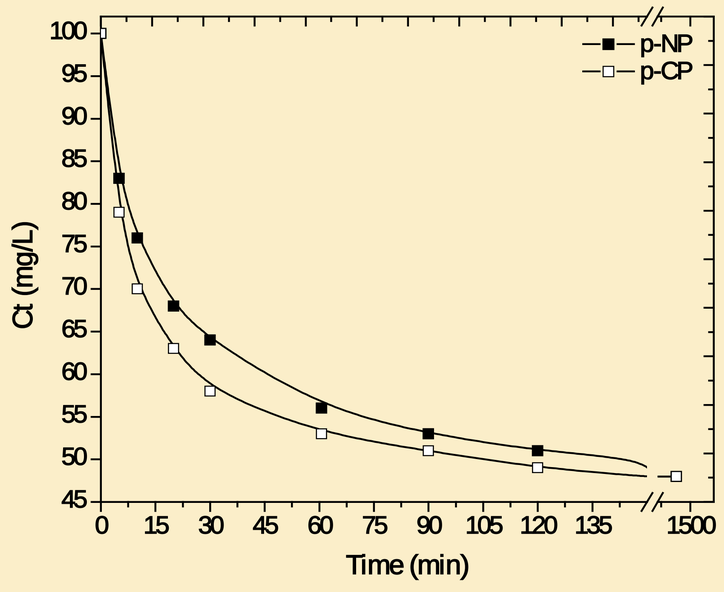
p-chlorophenol

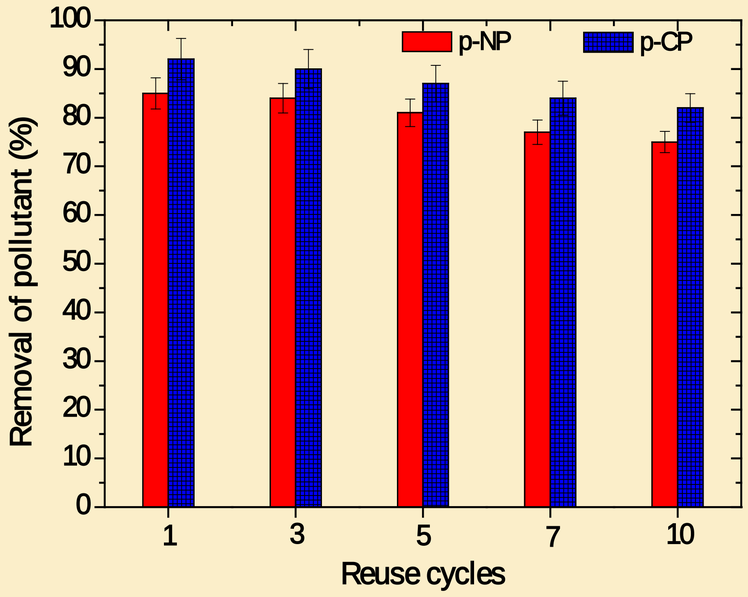


p-nitrophenol

Results







Acknowledgement

The financial support for this study was received from the Research Committee of Aristotle University of Thessaloniki (Greece) through the research program "Fellowships of Excellence for PostDoc Researchers (2013) – Awards of Excellence & Novelty from Research Committee of Aristotle University of Thessaloniki (Code 50141)" under the title "Synthesis, characterization and application of novel polymeric biosorbents for the environmental-friendly removal of various pollutants from industrial effluents", which is gratefully appreciated.

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