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Fast and efficient single step synthesis of modified magnetic nanocatalyst for catalytic reduction of 4-nitrophenol

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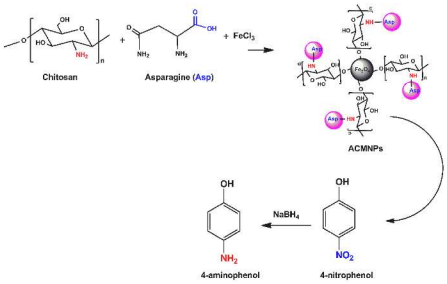
HIGHLIGHTS

- Fast synthesis of modified magnetic nanocatalyst in single step.
- Use of environment friendly modifiers which are low cost and highly abundant in nature.
- Amino-acid and biopolymer mediated synthesis.
- Conversion of toxic organic pollutant (4-nitrophenol) to useful one (4-aminophenol).
- Easy recovery of magnetic nanocatalyst with the help of external magnet.

GRAPHICAL ABSTRACT



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ABSTRACT

In this work, asparagine chitosan magnetic nanoparticles (ACMNPs) have been synthesized in single step using reduction-precipitation method. The synthesized nanoparticles were characterized using FTIR, SEM, HR-TEM, EDX, TGA, VSM, XRD and UV–Vis techniques. The shape of nanoparticles found was spherical as well as semi-spherical and the size obtained through HRTEM was 6.0–7.5 nm. EDX analysis showed the presence of elements such as carbon, nitrogen, oxygen, iron which confirmed the modification. The magnetic nanoparticles were found to be sufficiently magnetic as saturated magnetization value obtained with the help of VSM was 19.4 emu/g. The synthesized nanoparticles were applied for catalytic reduction of a toxic organic pollutant 4-nitrophenol (4-NP) to 4-aminophenol (4-AP) which has industrial and medical application. 4-Nitrophenol converted to 4-nitrophenolate ion in presence of $NaBH_4$ as reducing agent. On addition of ACMNPs nanocatalyst the 4-nitophenolate quickly converted to 4-aminophenol as confirmed by the color change from yellow to colorless in few minutes. The effect of parameters like amount of catalyst (10–25 mg) and temperature (25–55 °C) on time of catalysis were also evaluated. The results obtained showed that increasing both the amount of catalyst and temperature enhanced the catalysis rate. Increasing the amount of catalyst from 10 to 25 mg reduces the time of catalysis from 18 min to 6 min, while increasing the temperature from 25 °C −55 °C, reduces the catalytic time from 9 min to 4 min with 20 mg of nanocatalyst. The rate constant K_1 and activation energy obtained were 0.4681 min^{-1} and 24.03 kJ mol^{-1} respectively. Furthermore, the reusability of nanocatalyst was also studied and it was found that easy separation of magnetic nanocatalyst with the help of external magnet enhanced its reusability and the catalyst showed good reusability of up to 3 cycles.

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