Data Article

Data on the removal of Optilan Blue dye from aqueous media using starch-coated green synthesized magnetite nanoparticles

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ABSTRACT

In this data article, we present supplementary data related to the research article entitled “Starch-coated green synthesized magnetite nanoparticles for removal of textile dye Optilan Blue from aqueous media” Stan et al., 2019. Data interpretations are included in the related research article Stan et al., 2019. The synthesized starch-coated Fe3O4 nanoparticles (ST-coated Fe3O4 NPs) were analyzed by scanning electron microscopy (SEM) and high resolution transmission electron microscopy (HRTEM) to illustrate the shape and surface coating of nanoparticles. Moreover, the Brunauer-Emmett-Teller (BET) technique was used to evidence starch deposition on magnetite nanoparticles. The obtained nanocomposites were used for adsorption of Optilan Blue (OB) in batch conditions and the optimum agitation speed and point of zero charge (pHpzc) were established. After OB adsorption on ST-coated Fe3O4 NPs, the nanocomposites were analyzed by transmission electron microscopy (TEM), X-ray diffraction (XRD) and Fourier-transform infrared spectroscopy (FTIR). The stability of starch coated Fe3O4 NPs in the acidic as well as alkaline pH was also evidenced by FTIR spectroscopy. In addition, to test the
stability of ST-coated Fe₃O₄ NPs, leaching experiments were carried out. The experimental data were compared with isotherm and kinetic models in order to determine the most suitable for fitting.

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1. Data

The presented data are supplementary the research article of J Taiwan Inst Chem Eng 2019; 100:65-73 [1].

The XRD and TEM data for ST-coated Fe₃O₄ NPs after OB adsorption are summarized in Table 1. The adsorption capacity of the tested adsorbents was compared with other magnetic adsorbents.

### Table 1

| Magnetite nanoparticles | Starch-coated magnetite nanoparticles after OB dye adsorption |
|-------------------------|-------------------------------------------------------------|
|                         | XRD (nm) | TEM (nm) |
| Fe₃O₄(av1)             | 14       | 19       |
| Fe₃O₄(av2)             | 13       | 19       |
| Fe₃O₄(wm)              | 14       | 16       |
| Fe₃O₄                 | 16       | 18       |

* Abbreviations used: av1 — avocado peel extract, av2 — avocado seed extract, wm — watermelon seed extract, no extract. Additional information can be found in the research article [1].
used for dye removal in Table 2. Fig. 1 shows the SEM images of ST-coated \( \text{Fe}_3\text{O}_4 \) NPs, and the HRTEM images of two nanocomposite samples are illustrated in Fig. 2. The nitrogen adsorption-desorption isotherms and pore radius for \( \text{Fe}_3\text{O}_4 \) sample before and after starch coating are depicted in Fig. 3.

![Fig. 1. SEM images of ST-coated samples: (a) \( \text{Fe}_3\text{O}_4\text{av1} \), (b) \( \text{Fe}_3\text{O}_4\text{av2} \), (c) \( \text{Fe}_3\text{O}_4\text{wm} \) and (d) \( \text{Fe}_3\text{O}_4 \) samples.](image-url)

**Table 2**

| Magnetic Adsorbent | Dye                        | Isotherm | Adsorption capacity (mg g\(^{-1}\)) | Reference |
|-------------------|-----------------------------|----------|-------------------------------------|-----------|
| Chitosan coated \( \text{Fe}_3\text{O}_4 \) nanoparticles | Reactive Yellow 145 | Langmuir | 47.62 | [2] |
| Sodium alginate-coated \( \text{Fe}_3\text{O}_4 \) nanoparticles | Malachite green | Langmuir | 47.84 | [3] |
| PGA-coated \( \text{Fe}_3\text{O}_4 \) nanoparticles | Methylene blue | Langmuir | 78.67 | [4] |
| L-Serine functionalized \( \text{Fe}_3\text{O}_4 \) NPs | Rhodamine B | Langmuir | 6.82 | [5] |
| Magnetic \( \text{Fe}_3\text{O}_4@\text{SiO}_2 \) starch-graft-poly (acrylic acid) (SPAA) nanocomposite hydrogels | Crystal violet | Langmuir | 80.64 | [6] |
| MNP@St-g-PVS | Methylene blue | Langmuir | 621 | [7] |
| Lignin magnetic nanoparticles (LMNPs) | Methylene blue | Langmuir | 211.42 | [8] |
| Lignin amine magnetic nanoparticles (LAMNPs) | Acid scarlet GR | Langmuir | 176.49 | [8] |
| \( \text{Fe}_3\text{O}_4\text{Poly(styrene-co-methacrylic acid)} \) | Crystal violet | Langmuir | 416.66 | [9] |
| \( \text{Fe}_3\text{O}_4\text{Poly} \) | Rhodamine B | Langmuir | 69.54 | [9] |
| Chitosan coated \( \text{Fe}_3\text{O}_4 \) nanoparticles | Orange I | Langmuir | 180.8 | [10] |
| Starch-coated \( \text{Fe}_3\text{O}_4 \) NPs | Optilan blue | Langmuir | 86–125 | [1] |
TEM, XRD, FTIR and VSM analyses of nanocomposites after OB adsorption are presented in Figs. 4–8. FTIR analysis was employed to demonstrate the stability of adsorbents in the acidic as well as alkaline media and the spectroscopic evidences are shown in Fig. 9.

The effect of agitation speed on OB removal is presented in Fig. 10. The pH_{pzc} values for all adsorbents are determined by the position where the resulting curves cut through the pH_{initial} axis as observed in Fig. 11. Data from leaching experiments, carried out in order to establish complete magnetic separation and the total dissolved iron concentrations by ICP-OES analysis, are shown in Fig. 12. As illustrated in Fig. 13 and Fig. 14, adsorption isotherms and kinetics were modeled and fitted with

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**Fig. 2.** HR-TEM images of starch-coated: a) Fe₃O₄(av2) and b) Fe₃O₄ samples.

**Fig. 3.** Nitrogen adsorption-desorption isotherms and pore radius for Fe₃O₄ sample. before (A) and after starch coating (B).
experimental data in order to determine the interactions that occur between the adsorbent and adsorbate species, the adsorption rate by the adsorbent, and the adsorption mechanism of the solute onto an adsorbent.

2. Experimental design, materials, and methods

2.1. Materials

Starch-coated Fe$_3$O$_4$ NPs, Optilan Blue MF-GL dye, 0.5 N HCl or 5% NH$_4$OH for pH adjustments.

2.2. Determination of pH$_{pzc}$ of ST-coated Fe$_3$O$_4$ NPs

The pH drift method [11] was used to determine the pH at point of zero charge (pH$_{pzc}$) of the adsorbents under study. Over 12 mg of adsorbent, 20 mL of 0.01 M NaCl solution was added with the
initially pH adjusted in the range of 2–12 by adding 0.5 N HCl or 5% NH₄OH. The mixtures were left at room temperature for 48 h, after which the solid material was separated from the solution using an external magnet and the final pH value was measured.

2.3. Adsorption experiments

Optilan Blue adsorption on ST-coated Fe₃O₄ NPs was performed under batch conditions. The effect of initial dye concentration, pH, temperature and adsorbent dosage on adsorption of OB on ST-coated Fe₃O₄ NPs were determined. In addition, a study was conducted to determine the optimum agitation speed (100–500 rpm) at which the maximum dye adsorption was accomplished. The solution was adjusted with 0.5 N HCl or 5% NH₄OH in order to achieve the desired pH. The adsorbent was separated using an external magnet and the residual dye was measured with a
UV–Vis spectrophotometer, recording the absorbance at 629 nm. The obtained experimental data were fitted to different models in order to understand the adsorption behavior of OB on ST-coated Fe₃O₄ NPs.

In addition, the stability of adsorbents in acidic (pH 2) and alkaline (pH 10) media was investigated.

2.4. Characterization and analysis

The surface morphology of nanocomposites was examined from SEM and HRTEM images. BET measurements were also conducted, and evidenced the deposition of starch on the surfaces of magnetite nanoparticles.

Fig. 7. FTIR spectra of OB dye and starch-coated Fe₃O₄(av2) sample. before and after dye adsorption.

Fig. 8. The behavior of magnetization vs. the applied magnetic field for ST-coated Fe₃O₄ NPs after OB dye adsorption.
The stability of adsorbents was investigated in the acidic pH (2) as well as alkaline pH (10) by FTIR technique in order to underline the possible spectroscopic evidences.

After OB adsorption on ST-coated Fe₃O₄ NPs, the dried samples were characterized by different techniques such as FTIR, XRD, TEM, and VSM.

2.5. Batch leaching test

For each leaching test, 10 mg of ST-coated Fe₃O₄ NPs were mixed with 10 mL of water at pH 2 (HCl 0.1 M) in a 20 mL conical flask. The mixture was stirred with 500 rpm for 2 hours at different temperature (25 °C, 35 °C and 45 °C). The nanoparticles were separated using an external magnet and the leachate samples were analyzed by a dual viewing inductively coupled plasma optical emission spectrometer (ICP-OES). The experiment was performed in triplicate.
Fig. 10. The effect of agitation speed on OB removal.

Fig. 11. Point zero charge of ST-coated Fe3O4 NPs.

Fig. 12. The total dissolved iron concentrations.
Fig. 13. Adsorption isotherm models fitted to experimental adsorption of OB on ST-coated Fe$_{3}$O$_{4}$ NPs at different temperatures (pH 2, mass dosage 0.6 g L$^{-1}$).
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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Fig. 14. Adsorption rate curves (pH 2, dye conc. 50 mg L⁻¹, 308 K and adsorbent dose 0.6 g L⁻¹).
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