Journal of Photochemistry & Photobiology, B: Biology 165 (2016) 189–201

Contents lists available at ScienceDirect

Journal of Photochemistry & Photobiology, B: Biology

journal homepage: www.elsevier.com/locate/jphotobiol

Sorption isotherms, kinetic and optimization process of amino acid proline based polymer nanocomposite for the removal of selected textile dyes from industrial wastewater

Sharista Raghunath [a], K. Anand [a,*], R.M. Gengan [a,*], Mithil Kumar Nayunigari [b], Arjun Maity [b]

[a] Department of Chemistry, Faculty of Applied Sciences, Durban University of Technology, Durban, South Africa
[b] Department of Civil and Chemical Engineering, University of South Africa (UNISA), South Africa

ARTICLE INFO

Article history:
Received 29 August 2016
Accepted 11 October 2016
Available online 18 October 2016

Keywords:
Proline polymer
PRO-BEN
Adsorption kinetics
Reactive dyes
XPS

ABSTRACT

In this article, adsorption and kinetic studies were carried out on three textile dyes, namely Reactive Blue 222 (RB 222), Reactive Red 195 (RR 195) and Reactive Yellow 145 (RY 145). The dyes studied in a mixture were adsorbed under various conditions onto PRO-BEN, a bentonite modified with a new cationic proline polymer (L-proline-epichlorohydrin polymer). The proline polymer was characterized by ^{1}H NMR, Fourier transform infrared spectroscopy (FT-IR), dynamic light scattering (DLS) and TEM. The PRO-BEN composite was characterized by FT-IR, dynamic light scattering (DLS) (zeta potential), TEM imaging, SEM/EDX and X-ray photoelectron spectroscopy (characterize the binding energy). During adsorption studies, factors involving pH, temperature, the initial concentrations of the dyes and the quantity of PRO-BEN used during adsorption were established. The results revealed that the adsorption mechanism was categorized by the Langmuir type 1 isotherm. The adsorption data followed the pseudo-second order kinetic model. The intraparticle diffusion model indicated that adsorption did not only depend on the intraparticle diffusion of the dyes. The thermodynamic parameters verified that the adsorption process was spontaneous and exothermic. The Gibbs free energy values indicated that physisorption had occurred. Successful adsorption of dyes from an industrial effluent was achieved. Desorption studies concluded that PRO-BEN desorbed the dyes better than alumina. This can thereby be viewed as a recyclable remediation material. The PRO-BEN composite could be a cost efficient alternative towards the removal of organic dyes in wastewater treatment.

1. Introduction

Synthetic dyes are used for many applications such as coloring food, leather, textiles, paper, drugs, cosmetics, for printing inks, varnishes, paints, oils and soaps [1,2,3]. Consequently, these dyes make their way into public water systems, dams, lakes and the sea as a result of escaping industrial and domestic effluent. This poses major health risks for both humans and aquatic life since most of these dyes are carcinogenic and can clearly be distinguished at low concentrations [2]. Synthetic dyes are classified into three groups, namely anionic dyes (acid dyes, reactive dyes, and direct dyes), cationic dyes (basic dyes) and non-ionic dyes (vat dyes and disperse dyes) [4]. Textile dyes have intense colour and are non-biodegradable [5]. Nearly 2% of the dyes utilized in the textile industry leave as effluent. As a result, the estimated concentration of dyes in wastewater is around 10–200 ppm. This low concentration is still visible in the environment.

There are many ways of removing organic compounds from wastewater or effluent, including mixed dyes in water or a single dye in water [9]. Some of these methods extend outside the scope of dyes alone due to their versatility. These include oxidation using sludge [6], through coagulation [7], ion-exchange membranes, via adsorption and through the use of nanotechnology [8–17]. Adsorption is the most preferred method due to its low cost, adsorbents are easily available, it yields excellent results and it can be reused. In past studies, adsorbents such as silica [18], cellulose [19], activated carbon [20] and hen feathers [2] were used to remove dyes through adsorption, however, some were expensive, not easily attained and required tedious preparations before the adsorption process.

Studies in the past had revealed successful incorporation of physical modifications [21] and surfactants and ionic polymers [22]. Ionic polymers are charged polymers bearing at least one quaternary ion (NH_4^+) in its structure. This attributes to its solubility in water. This is advantageous in bentonite modification where water is used as a medium. The polymer renders the surface of the bentonite hydrophobic due to its large organic body and thus increasing the adsorption capabilities of bentonite towards organic pollutants [23]. Ionic polymers are no

* Corresponding authors.
E-mail addresses: organicanand@gmail.com (K. Anand), genganrm@dut.ac.za (R.M. Gengan).

http://dx.doi.org/10.1016/j.jphotobiol.2016.10.012

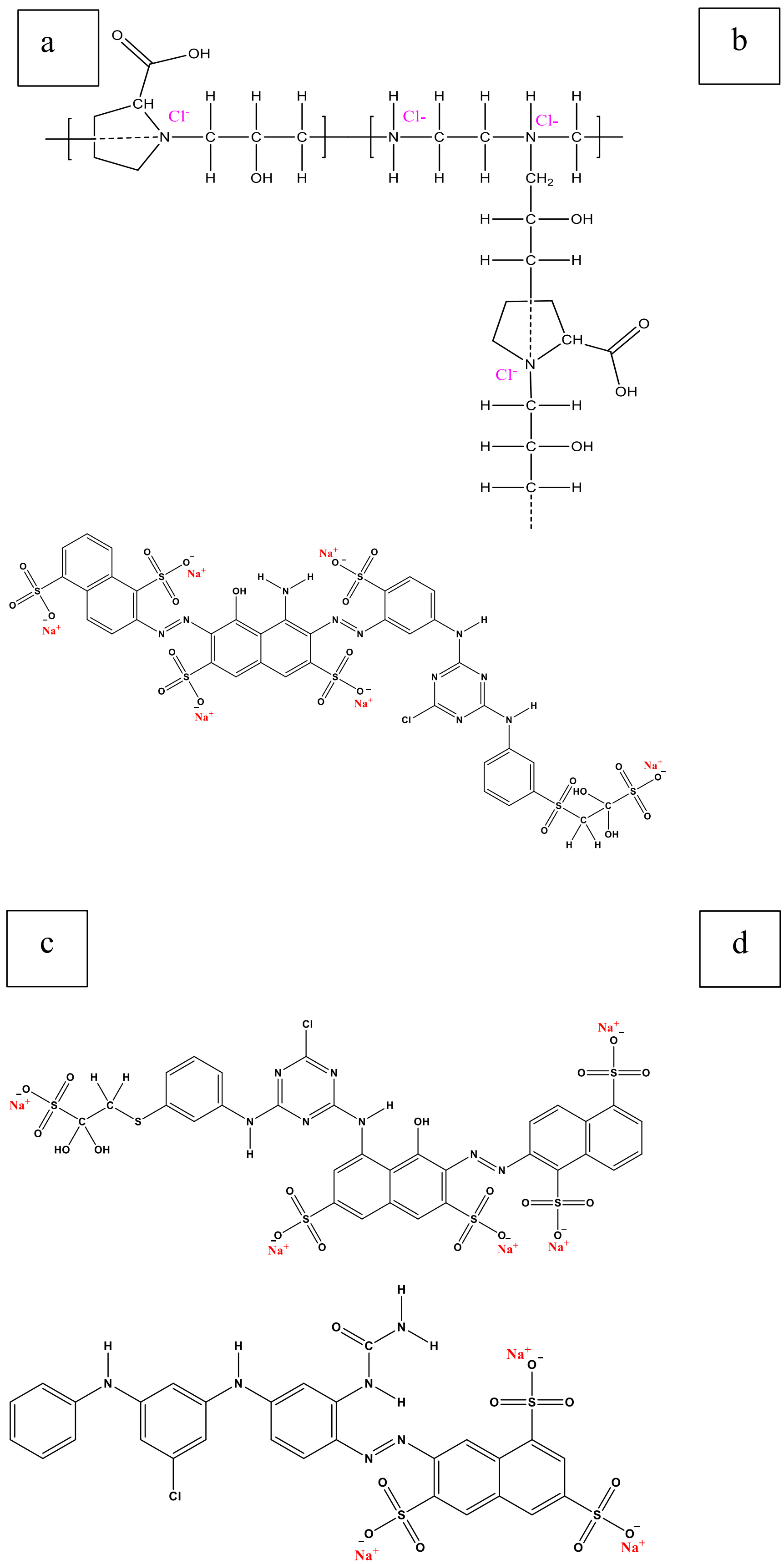

Fig. 1. Chemical structures of (a) proline polymer, (b) Reactive Blue 222, (c) Reactive Red 195 and (d) Reactive Yellow 145.