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Modeling wastewater biodecolorization with reactive blue 4 in fixed bed bioreactor by *Trametes subectypus*: Biokinetic, biosorption and transport

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HIGHLIGHTS

- A biodecolorizaton model with biosorption and biodegradation was developed.
- The biokinetic parameters were determined by fit to Contois model.
- The biosorption parameters were determined by fit to Langmuir model.
- Model predicted *Trametes subectypus* limits to biodecolorize polluted influent.
- A sorption-reaction dimensionless module (ϕ) is proposed like process criterion.

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ABSTRACT

A biodecolorization model that considers the simultaneous mechanism of biosorption and biodegradation of a synthetic dye by immobilized white-rot fungus *Trametes subectypus* B32 in a fixed bed bioreactor was developed. The model parameters (biokinetic, biosorption and macroscopic transport) were determined by independent experiments. The biodecolorization model was used to determine the effect of variables such as immobilized biomass content, volumetric flow of wastewater, dye feeding concentration and initial dye concentration. By means of the model was possible to predict in the steady state, the limits of immobilized *T. subectypus* to biodecolorize polluted influent, being the model predictions similar in extent to previous reports. A dimensionless module of biosorption-bioreaction ($\phi = q_{max}\, v_z / r_{max}\, L$) was proposed to be used like criterion whenever one of the two mechanisms controls the biodecolorization. The model could be used for the designing and scaling up of fixed bed bioreactors with immobilized white-rot fungi for the biodecolorization process.

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1. Introduction

Synthetic dyes are an extended class of highly stable chemical compounds, present in the wastewater discharged by the textile industries. Around 10–15% of all dyes are lost directly on the wastewater, and have become one of the most common pollutants of natural water bodies (Rodríguez-Couto, 2009). The pollution by dyes leads to reduction of sunlight penetration, which decreases

Abbreviations: τ, Hydraulic time of RB4 dye (h); ε, Void space fraction inside fixed bed bioreactor (dimensionless V_f/V_{Total}); η, Quotient between support volume and void space volume (dimensionless $V_{support}/V_f$); σ^2, Variance of residence time of RB4 dye (h^2); ρ_x, Fungal biomass density (g L^{-1}); μ_{max}, Maximum specific growth rate (h^{-1}); β, Contois model parameter defined as apparent saturation constant (mg g^{-1}); D, Dispersion coefficient ($dm^2\ h^{-1}$); $E(t)$, RB4 dye function residence time distribution (h^{-1}); fv_x, Volumetric fraction of immobilized biomass (dimensionless); K, Affinity constant between biomass and dye (mg L^{-1}); k_D, Specific cellular decay rate (h^{-1}); m_x, Total amount of biomass immobilized (g); Pe, Peclet number ($v_z \cdot L/D$, dimensionless); ϕ, Sorption-reaction module ($q_{max}\, v_z / r_{max} L$, dimensionless); q, Dye mass biosorbed by specific quantity of fungal biomass (mg g^{-1}); q_{max}, Maximum amount of dye sorbed by specific unit of biomass (mg g^{-1}); r_{biod}, Dye biodegradation rate (mg $L^{-1}\ h^{-1}$); $r_{biosorp}$, Dye biosorption rate (mg $L^{-1}\ h^{-1}$); r_{max}, Maximum specific biodecolorization rate of dye (mg $g^{-1}\ h^{-1}$); s, $s(t,z)$, Concentration of dye RB4 at any time along of the fixed bed bioreactor (mg L^{-1}); s_l, $s(t,l)$, Concentration of dye RB4 at the output of the fixed bed bioreactor at any time(mg L^{-1}); s_o, $s(t,0)$, Concentration of dye RB4 feeding to the fixed bed bioreactor at any time (mg L^{-1}); s_z, $s(0,z)$, Concentration of dye RB4 along of the fixed bed bioreactor at $t = 0$ (mg L^{-1}); t, Time (h); z, Axial position along of the fixed bed bioreactor (dm); L, Length of the fixed bed bioreactor (dm); t_m, Average residence time of RB4 dye inside the fixed bed bioreactor (h); V_f, Void space volume (L); $V_{support}$, Support inside the fixed bed bioreactor volume (L); V_{Total}, Total volume of the fixed bed bioreactor (L); V_x, Immobilized biomass volume (L); v_z, Fluid axial average velocity (dm h^{-1}); x, Biomass concentration (mg L^{-1}).

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