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**Hematite flotation using a crude
biosurfactant extracted from
*Rhodococcus opacus***

Dissertação de Mestrado

Dissertation presented to the Programa de Pós-graduação em Engenharia de Materiais e Processos Químicos e Metalúrgicos, PUC-Rio as partial fulfilment of the requirements for the degree of Mestre em Engenharia de Materiais e Processos Químicos e Metalúrgicos.

Advisor: Prof. Mauricio Leonardo Torem
Co-advisor: Dr. Antonio Gutiérrez Merma

Rio de Janeiro
July 2016



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Abstract

Puelles, Jhonatan Gerardo Soto; Torem, Mauricio Leonardo (Advisor); Merma, Antonio Gutiérrez (Co-advisor). **Hematite flotation using a crude biosurfactant extracted from *Rhodococcus opacus***. Rio de Janeiro, 2016. 110p. MSc. Dissertation -Departamento de Engenharia Química e de Materiais, Pontifícia Universidade Católica do Rio de Janeiro.

Bioflotation is defined as a separation process by which the mineral of interest is floated or depressed selectively, using reagents of biologic origin also known as bioreagents. These substances are characterized by their green chemistry, selectivity and potential to treat fine particles. Currently they are been studied with the expectative of substitute the synthetic reagents used in the mineral flotation processes. Between the diverse microorganisms, the hydrophobic bacteria *Rhodococcus opacus* has been studied as biofrother and biocollector in hematite flotation. In that sense, the research's principal objective is the assessment of the hematite floatability using a crude biosurfactant extracted from the bacteria *Rhodococcus opacus* and consequently determine its potential as an alternative against synthetic reagents or the bacteria itself. In a first stage, it was developed a protocol for the extraction of cell associated and intracellular biosurfactants from the bacteria. Throughout ethanol extraction at 121°C and 2 atm, the cell associated substances where released and solubilized. The average crude biosurfactant recovery was around 0.3 g per L of broth. Characterization by FTIR identified alcohol (-OH) and ketone (C=O) groups as well as saturated and unsaturated carbon chains. Which may compose the mycolates and trehalolopids that are found in the cellular wall of the genera *Rhodococci*. Electrophoretic studies of the hematite sample, before BS interaction, found an IEP around a pH of 7.5 and a PZC at pH 7.6. Applying the Guoy-Chapman model and the mixed model of Guoy Chapman and the plate capacitor, it was possible to study the effect of the biosurfactant onto the electrostatic behavior of the hematite particles. The model predicted the hydrophobicity of the modified hematite at acid pH. Finally it was tested the crude biosurfactant against the bacteria itself in microflotation tests, resulting the first one

in an improved hematite floatability. The results showed a high affinity of the crude biosurfactant for hematite particles and relatively low reagent consumption.

Keywords

Hematite; bioflotation; *Rhodococcus opacus*; biosurfactant.

Resumo

Puelles, Jhonatan Gerardo Soto; Torem, Mauricio Leonardo; Merma, Antonio Gutiérrez. **Flotação de hematita usando um biosurfactante não refinado extraído da *Rhodococcus opacus***. Rio de Janeiro, 2016. 110p. Dissertação de Mestrado -Departamento de Engenharia Química e de Materiais, Pontifícia Universidade Católica do Rio de Janeiro.

A bioflotação é definida como um processo de separação, através do qual o mineral de interesse é flotado ou deprimido seletivamente, utilizando os reagentes de origem biológica, também conhecidos como bioreagentes. Estas substâncias são caracterizadas por possuírem uma química verde, seletividade e potencial para tratar partículas finas. Neste sentido, o objetivo principal da pesquisa é a avaliação de um biosurfactante não refinado extraído da bactéria *Rhodococcus opacus* na flotação de hematita. Na primeira fase, foi desenvolvido um protocolo para a extração dos biosurfactantes intracelulares e aqueles associados a parede celular da bactéria. Mediante extração com etanol a 121°C e 2 atm, as substâncias anfífilas foram liberadas e solubilizadas. A recuperação média de biosurfactante não refinado foi de 0,3 g por dm⁻³. A caracterização por FTIR identificou grupos álcool (-OH), cetona (C = O) e cadeias de carbono saturadas e insaturadas. Que podem compor os mycolatas e trehalolipídeos que são encontrados na parede celular da bactéria. Por estudos eletroforéticos encontrou-se um PIE de 7,5 e um PZC em torno de 7,6. Aplicando o modelo Gouy-Chapman e o modelo misto de Gouy Chapman e o capacitor de placas, foi possível estudar o efeito do biosurfactante no comportamento eletrostático das partículas de hematita. Predizendo como elas foram se tornando hidrofóbicas em valores de pH ácido e como sua flotabilidade diminuía em pH básicos, após interação com o biosurfactante. Finalmente, foi testado o biosurfactante e a própria bactéria em ensaios de microflotação de hematita, resultando o primeiro na melhora na flotabilidade de hematita. Os resultados mostraram uma boa afinidade e baixo consumo de reagente.

Palavras-chave

Hematita; bioflotação; *Rhodococcus opacus*; biosurfactante.

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List of symbols

Latin characters:

<i>BS</i>	Biosurfactant
<i>CMC</i>	Critical micelle concentration
c_{zp}	Ion concentration at the point of zero charge, mol dm ⁻³
c_0	Initial ion concentration, mol dm ⁻³
F	Faraday constant, 96 485.3 s A mol ⁻¹
<i>IEP</i>	Isoelectric point
k_B	Boltzman constant, 1.38E-23 m ² kg s ⁻² K ⁻¹
<i>PZC</i>	Point of zero charge
R	Universal gas constant, 8.314 J K ⁻¹ mol ⁻¹
T	Absolute temperature, K
x	Distance from the particle surface, m

Greek characters:

ΔG	Free energy Gibbs variation, J m ⁻²
D	Debye length, m
ϕ	Surface potential, mV
ϵ_0	Vacuum permittivity
ϵ_r	Dielectric constant of water
	Distance between the opposite charges
	Charge density per area, C m ⁻²
ρ	Charge density per volume, C m ⁻³

*“People don't choose dreams,
dreams choose you” I.W.*