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Purification of platinum group metals process stream using saccharomyces cerevisiae waste yeast biomass

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ABSTRACT

The removal of platinum group metals (PGMs) from dilute process streams is essential due to their economic value and the increasing need to recycle process water. This study presents the removal of Pd (II), Ir (III), Pt (II), Rh (III) and Au (III), from synthetic multicomponent aqueous solution in a batch system using untreated, NaOH treated and ethanol treated Saccharomyces cerevisiae waste biomass obtained as a byproduct of brewery fermentation industry. A two-level four factor full-factorial experimental design and analysis was successfully employed for the testwork. The effects of pH, initial metal ion concentration, temperature and biomass dosage on PGMs removal were assessed using the design of experiment (DOE) approach. Solution pH and initial metal concentration were found to be statistically significant for the adsorption of PGMs tested. Ethanol treated biomass gave the highest adsorption uptake for all the PGMs tested. The sorption uptake is in the order of $Au^{3+}>Pd^{2+}>Pt^{2+}>Ir^{3+}>Rh^{3+}$. The overall maximum sorption attained was 99.9% for Au (III), 91% for Pt (II), 99.5% for Pd (II), 81.9% for Ir (III) and 81.1% for Rh (III).

The desorption of the tested PGMs from the loaded biomass was carried out using different concentrations of hydrochloric acid, sulphuric acid, thiourea and hydrochloric – thiourea solution. Effective desorption was obtained using acidified 0.1M thiourea which can be explained as due to both stable complex formation and the electrostatic interaction between some of the PGMs species and charged species from elution. The biosorbent was successfully regenerated and reused up to 5 cycles.

Equilibrium data for metal removal in the batch study conformed well to the Langmuir isotherm except for the fitting of Pd (II) which complied with Freundlich isotherm model. Kinetic data were fitted to Lagergren first –order, pseudo second – order, Intraparticle diffusion and Elovich models. The kinetic parameters, rate constants, equilibrium adsorption capacities and related correlation coefficients for each kinetic model were calculated and discussed. Consequently, the adsorption of Pd (II), Ir (III), Pt (II), Rh (III) and Au (III) were found to follow a pseudo- second order kinetic model suggesting chemisorption of all the tested PGMs.

In addition, column studies were conducted for the purification of real dilute process stream from Impala Platinum using ethanol treated yeast immobilized on Plaster of Paris (POP). These studies focused not only on the PGMs but base metals and other trace elements present in the dilute solution. The breakthrough curve for most of the element do not resemble those of an

ideal breakthrough curve due to the complexity of the solution and the normalized concentration (C/C_o) for most of the metals in solution remained high even in the early stages of treatment when the sorbent material was most pristine. Generally, the affinity of the sorbent for the elements considered follow the order Pd^{2+}> SO_4^{2-}>Te^{2+}>Pt^{2+}>Ir^{3+}>Ni^{2+}>Cl^- >.Ru^{3+}>Se^{2+}> Na^+.

The data from the column studies was fitted into Adam-Bohart and Thomas model and the data conformed well to Adam – Bohart model. In general, ethanol treated S.cerevisiae yeast biomass appeared to be a good sorbent for the effective removal of PGMs but the complexity of the industrial wastewater requires that pretreatment steps be taken to reduce chloride and sulphate concentration in the solution before this process can be applied successfully.