HEAVY METAL REMOVAL BY YEAST STRAINS

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ABSTRACT

Cu^{2+} removal from aqueous solutions (0.1mM) was compared using viable cells of two yeast strains, grown both in the presence and in the absence of the metal. The flocculent yeast strain (*S. cerevisiae* NRRL Y265) presented significantly higher removal yields in both cases (respectively, 62 and 99% versus 7 and 12% for the non-flocculent strain of *S. carlsbergensis*).

The effect of the ion metal concentration on the biosorption capacity of *S. cerevisiae* NRRL Y265 was also tested in aqueous solutions of Cu^{2+}, Cd^{2+} and Pb^{2+} (0.1, 0.25, 0.5 and 1mM). Cells were more efficient for Pb^{2+} removal (90-100%) than for the others, being Cu^{2+} the least biosorbed ion.

While for Pb^{2+} there was no yield modification with concentration, for the other two ions a significant yield decrease was observed with the increase of ion concentration. On the contrary, in aqueous mixtures of two or three of these cations, only for the highest concentration tested (1mM) was a removal yield decrease observed. Similar data were obtained with non-viable cells of another flocculent yeast from a brewing industry (UNICER).

In every system analysed, Pb^{2+} was always preferentially removed, leading to the highest removal yields (85-100%). The best results were obtained with the flocculent *S. cerevisiae* strain from UNICER.

Key words: Biosorption, Copper, Cadmium, Lead, removal, yeasts, flocculent

1. INTRODUCTION

Many yeasts and other microorganisms are known to be capable of concentrating metal species from dilute aqueous solutions and accumulating them within their structure.

Metal ion uptake can be obtained by physical adsorption or ion exchange at the cell surface of living or non-living biomass. Because of these properties, various microorganisms have been used for the treatment of industrial wastewaters containing toxic heavy-metal cations (1).

3. RESULTS AND DISCUSSION

a) Ion removal by two different yeast strains

Previous results had showed that a low ion removal was obtained when viable cells of a non-flocculent strain of *S. carlsbergensis* were used (2). A comparision between the latter and a flocculent strain (*S. cerevisiae* NRRL Y265) was done for Cu^{2+} removal (Table 1).

Viable cells grown both in the presence and in the absence of the ion metal, and harvested in the end of the exponential growth phase, were used. The flocculent yeast strain presented a significantly higher removal capacity in both cases. The high value observed with cells grown in the presence of the metal can in part be attributed to the high cell density per unit area achieved with this strain (3). This fact can be of great interest in scale-up processes to optimise industrial effluent purification.

Table1 - Biosorption of Cu^{2+} (0.1mM in solution) by two different yeast strains

BIOMASS	REMOVAL YIELD (%)	
	Saccharomyces carlsbergensis	*Saccharomyces cerevisiae* NRRL Y265
Growing in the presence of metal	12	99
Harvested in the end of exponential growth phase	7	62

b) Effect of the heavy metal concentration on the yeast biosorption capacity

Cells of *S. cerevisiae* NRRL Y265, harvested in the end of the exponential growth phase, were used for Cu^{2+}, Cd^{2+} and Pb^{2+} removal from aqueous solutions of ion increasing concentration (0.1, 0.25, 0.5 and 1mM) (Figure 1a). Results showed that, with the exception of Pb^{2+}, biosorption decreased with the increase of metal concentration, probably because of the biosorbent saturation. Pb^{2+} was the cation that led to the highest removal yields, which is in agreement with the fact referred by Tobin (4) and also observed by Fourest and Roux (5) that, usually, the molar adsorption capacity increases with the atomic weights of the elements.

The lowest results in terms of removal yields were obtained for copper, being observed a decrease of 62 to 23% with the 0.1 to 1mM ion concentration increase. Nevertheless, ion removal was always very fast regardless of the concentration and the maximum uptake was obtained up to 1 hour of contact (Figure 1b).

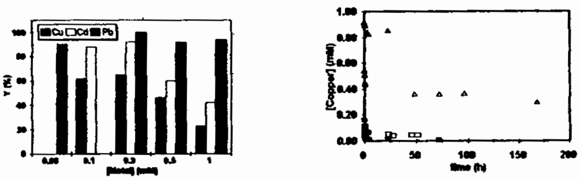

Figure 1 - a) Effect of the cation concentration on the biosorption capacity of *S. cerevisiae* NRRL Y265 cells; **b)** Cu^{2+} uptake with time for different initial concentrations:(□)0.1 mM; (■)=0.2 mM;(Δ)0.5 mM and (▲)1 mM.

c) Metal Sorption Selectivity

Yeast removal capacity in one, two and three metal sorption systems using two different flocculent yeasts, one of them grown in laboratory and harvested in the end of the exponential phase (Fig. 2) and the other from a brewing industry (UNICER) (Table 2), was compared.

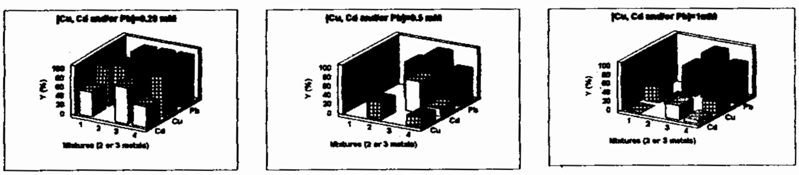

Figure 2 - Effect of the heavy metal mixtures and concentration on the biosorption of Cu^{2+}, Cd^{2+} and Pb^{2+} by *S. cerevisiae* NRRL Y265 cells harvested in early stationary phase. Metal mixtures: 1-Cu^{2+}+Cd^{2+};2- Cu^{2+}+Pb^{2+};3- Cd^{2+}+Pb^{2+};4- Cu^{2+}+Cd^{2+} +Pb^{2+}.

Table 2 - Effect of the heavy metal mixtures and concentration on the biosorption by *S. cerevisiae* cells from from UNICER.

Metals	Metal concentration (mM)			Metal Removal (%)		
	Cu^{2+}	Cd^{2+}	Pb^{2+}	Cu^{2+}	Cd^{2+}	Pb^{2+}
Cu^{2+}+Pb^{2+}	0.11		0.11	57		92
	0.27		0.27	66		91
	0.60		0.60	84		100
	1.10		1.00	14		100
Cu^{2+}+Cd^{2+}	0.12	0.12		79	79	
	0.27	0.40		32	95	
	0.60	0.60		63	93	
	1.20	1.40		18	6	
Cd^{2+}+Pb^{2+}		0.11	0.11		60	83
		0.40	0.27		80	82
		0.60	0.60		80	92
		1.40	0.90		50	100
Cu^{2+}+Pb^{2+}+Cd^{2+}	0.11	0.10	0.10	69	80	83
	0.27	0.28	0.24	46	92	90
	0.60	0.60	0.70	54	80	100
	1.30	1.30	0.9	36	20	100

Results showed that, in solutions containing mixtures of two or three cations, a biosorption selection occurred for both yeasts, their removal capacity increasing in the order Cu^{2+}<Cd^{2+}<Pb^{2+}. However, removal yields decreased significantly when the ternary system, in comparision with one and two-metal systems, was tested for all the ion initial concentrations used, showing a ion competition for the yeast binding sites.

In the ion mixtures, for ion concentrations between 0.1 and 0.5mM removal yields by both yeasts varied randomly depending on the cations involved. On the contrary, for the highest ion concentration tested, the yields suffered a marked decrease. The ion concentration increase enhances the metal/biosorbent ratio and probably increases the metal uptake per gram of biosorbent, as long as the latter is not saturated.

Finally, the results obtained for metal removal by the yeast *S. cerevisiae* from UNICER (Table 2) were better than the ones obtained with the other strain. This can be a consequence of the non-living biomass from brewery having been exposed, during large periods of time, to the ethanol concentrations resulting from the fermentation process, which can change the cell membrane structure in terms of its integrity and the number of anionic groups capable of binding to Cu^{2+}, Cd^{2+} and Pb^{2+}.

Experiments with a non-flocculent yeast from another brewing industry are also being carried out in order to compare its biosorption capacity with *S. cerevisiae*'s from UNICER.

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