Available online at www.sciencedirect.com
ScienceDirect
Reactive & Functional Polymers 66 (2006) 1494–1505
REACTIVE & FUNCTIONAL POLYMERS
www.elsevier.com/locate/react

Recovery of benzaldehyde from aqueous streams using extractant impregnated resins

Katarina Babić *, Louis van der Ham, André de Haan

Separation Technology Group, Faculty of Science and Technology, University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands

Received 21 December 2005; received in revised form 6 April 2006; accepted 29 April 2006
Available online 23 June 2006

Abstract

The performance of Extractant Impregnated Resin (EIR) technology for extraction of aldehydes from aqueous solutions has been investigated. The extraction capabilities of several different aliphatic and aromatic primary amines towards aldehydes were tested and compared. Aliphatic amines showed high affinity. The most promising extractant, Primene® JM-T, was immobilized in a porous particle. As a solid support three different macroporous adsorbents were tested, XAD-16, MPP and Stamypor. Their capacities for the removal of aldehydes were compared with the non-impregnated resin and the resin impregnated with the non-reactive solvent. It was shown that the addition of a reactive extractant can increase the adsorption capacity of an otherwise poor adsorbent for several orders of magnitude. The capacity for the removal of aldehydes was increased with the increase of amine loading on the particle. Temperature influence on the sorption of benzaldehyde on fully impregnated MPP was studied. It was shown that with temperature increase, sorption capacity is increased. The stability of EIRs regarding the loss of the extractant due to the leakage in water was also studied. It was shown that immobilization reduces the extractant's solubility in water. Sorption kinetics was investigated for fully impregnated XAD-16 and MPP. The modified shrinking core model was used to determine the rate controlling step and it was shown that this sorption is most likely controlled by both chemical reaction and diffusion in the particle.

Keywords: Extractant impregnated resins; Aldehydes; Amines; Reactive extraction; Adsorption

1. Introduction

Aqueous solutions containing components present in low concentrations are the result of many industrial processes. Very often it is necessary to recover them from these streams, either to obtain a valuable product or to prevent contamination of the environment. Therefore, it is desirable to reduce their presence in water to very low concentrations (ppb-level), rendering conventional reactive extraction unfeasible due to the high excess of solvent/reactant required. On the other hand, adsorption is very often not selective enough, has very low capacity or is very expensive when resins containing functional groups are used.

* Corresponding author. Tel.: + 31 53 489 2921; fax: + 31 53 489 4821.
E-mail address: k.babic@tnw.utwente.nl (K. Babić).

1381-5148/$ - see front matter
doi:10.1016/j.reactfunctpolym.2006.04.013

Nomenclature

Symbols

n	amount of substance, mol
C	concentration, mol/l
K_r	reaction equilibrium constant, l/mol
K_{ph}	physical partitioning ratio
D	overall distribution ratio, defined by Eq. (3)
V	volume, l
t	time, s
q	loading of the particles with benzaldehyde, mol/l
q_{JMT}	loading of the particle with Primene® JM-T, mol/l
X	fractional conversion of the EIR at time t, defined by Eq. (7)
X_e	fractional conversion of the outer surface of the EIR, defined by Eq. (8)
K	equilibrium distribution ratio of benzaldehyde between particle and water
a	average radius of the particle, m
δ	thickness of the stagnant liquid film, m
b	stoichiometric coefficient
D_e	effective diffusivity in the resin phase
D_f	diffusivity in the liquid film
K_c	apparent chemical reaction rate constant

Subscripts and superscripts

org	organic
aq	aqueous
Ald	aldehyde
Am	amine
AldAm	complex formed by aldehyde and amine (Schiff base)
o	initial

Component abbreviations

1-PD	1-phenyldodecane
SQ	squalene
MBDIPA	4,4′-methylenebis-(2,6-diidopropylaniline)
MBIPMA	4,4′-methylenebis-(2-isopropyl-6-methylaniline)
ODA	octadecylamine
DDA	dodecylamine
JM-T	Primene® JM-T

As a process that can overcome these disadvantages, but maintain the advantages of both mentioned separation techniques, Extractant Impregnated Resin (EIR) technology is proposed [1]. It is a synergistic combination of adsorption and reactive extraction that combines a high capacity and selectivity with relatively simple equipment and operation. Already a lot of research has been done in this field for removal of traces of metals from aqueous streams [2–4]. Lately, the EIR technology has been extended for recovery of organic compounds, like phenols [5], flavonoids [6], carboxylic acids [7–10], amino acids [11,12], and antibiotics (spiramycin [13]). In the present research, we investigate the removal of aldehydes from diluted aqueous streams using EIR technology, which has,

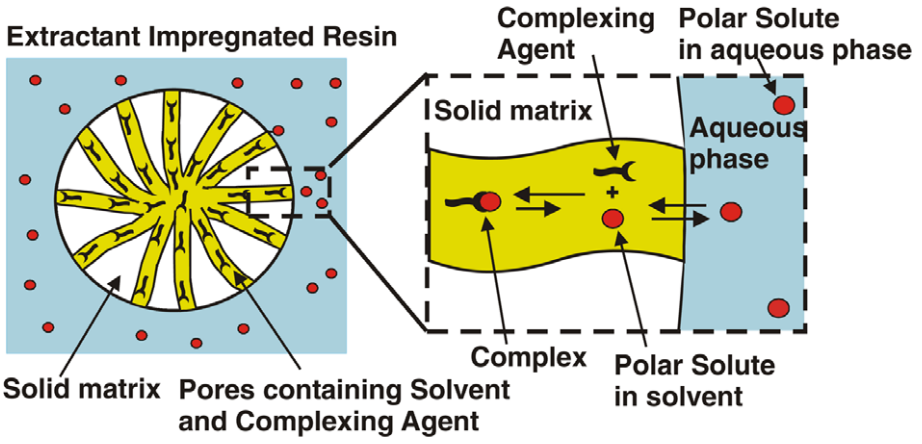

Fig. 1. Extractant impregnated resins.