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BREAKTHROUGH CURVE STUDIES OF PUROLITE A-400 IN AN ADSORPTION COLUMN

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Abstract

Ion-exchange adsorption of salicylic acid by strongly-base anion exchange resin PUROLITE A-400 was investigated to define the effect of feed flow rate on breakthrough curves and mass transfer coefficient. The equilibrium conditions by the usage of batch test were investigated. Two isotherm models Feroundlich and Langmuir fit the entire experimental data well (R^2> 98%). Series of column test at different three flow rates (5.5, 7 and 8.5ml/min) were performed. As a result of column test experiment breakthrough curves and mass transfer coefficient by the usage of constant wave propagation theory were obtained. As the results showed volumetric feed flow rates are increased by the increasing of feed flow rates in contrast of the maximum amount of adsorption. So that we should be determined optimize flow rate for the adsorption process.

Key words: ion-exchange; mass transfer; breakthrough; PUROLITE A-400; Salicylic acid.

1. Introduction

There has been a great concern for public health and environment over the last few decades. Methods like aeration, biological degradation, chemical oxidation, photo oxidation, solvent extraction and adsorption have been developed for the removal of organics from wastewater [1,2]. Of all these methods solvent extraction and adsorption are the most commonly used methods.

Recently, ion-exchange resin adsorbents have shown their ability in the organics removal and have been viewed as an alternative to activated carbon. Such resins act selectively as an adsorbent of processed acid, while other components of the raw solution flow by [3].

Phenolic compounds are undesirable pollutants in the environment, specifically in aquatic media. Salicylic acid is a phenolic compound, which is its precursor; it is present in wastewaters from different industries.

Adsorption of phenolic compounds onto different polymeric adsorbents has been studied by various groups [4–7]. Salicylic acid is a drug compound that nowadays is usually produced from phenol [8]. Some applications of salicylic acid are cosmetics, wart-removing medicines, to externally treat fungus infections, as an acne topic treatment and to increase the cell turnover as a component of skin creams [9,10].

To properly design and operate fix-bed adsorption processes, the fix-bed dynamics, that is, the pollutant breakthrough curves, must be known.

So, the adsorptions of salicylic acid onto PUROLITE A-400 as an anion-exchange resin to investigate the effect of feed flow rate on break through curves and mass transfer coefficient by the usage of constant wave propagation theory were the aim of this work.

2. Experimental

The aim of the presented investigations was evaluation of the applicability of strongly-based anion-exchange resin in salicylic acid purification. Experiments were carried out at batch and column tests in order to investigate equilibrium and dynamic condition of salicylic acid adsorption process, respectively.

Salicylic acid (C7H6O3) was purchased–Aldrich from Sigma (Spain). The experiments covered strongly-base anionic resins available on the market: PUROLITE A-400.

The adsorption isotherm of salicylic acid onto PUROLITE A-400 was experimentally determined by batch tests at varying initial concentration (0.4, 0.5, 0.6, 0.7and 0.8gr/lit) of salicylic acid solutions with the same weight of resins that added to the glass stoppered flasks. Then the flasks were shaken at 160 rpm and room temperature (at about 25°C) for 2 days to attain equilibrium. The amounts of salicylic acid adsorbed onto the PUROLITE A-400 were calculated from the mass balance relation.

Series of column tests were carried out continuously in glass mini-columns with an inside diameter of 1cm and a length of 12 cm.Column tests were performed at different volumetric flow rates (5.5, 7, 8.5 ml/min) to investigate the effect of flow rates on breakthrough curves and volumetric mass transfer coefficient.

A peristaltic pump (SP311-Welp) was used to pump the salicylic acid solution (initial concentration of 0.6gr/lit) in upward flow until the inlet acid concentration was achieved in the outlet stream. The temperature of the feed was maintained at about 25°C.

Samples were collected periodically and analyzed. In all experiments salicylic acid concentration was spectrophotometrically determined at 295nm, by an UV-vis spectrophotometer Jasco (model 7800, Japan).

3. Result and discussion

At first, the adsorption isotherms of salicylic acid at 25°C and varying solution concentration were measured and the experimental data were fitted with two isotherm models. The Langmuir and Froundlich isotherm models were found to fit all of the experimental data well (for both R^2 are more than 96%).

A series of column tests were also performed to determine the breakthrough curves behavior at three different flow rates (5.5, 7, and 8.5, ml/min) to investigate the effect of flow rates on breakthrough curves and volumetric mass transfer coeff.

Fig. 1. represents the experimental results obtained on PUROLITE A-400 with the salicylic acid feed rates of 5.5,7and 8.5 ml/min and solution initial concentration of 0.6gr/lit. The results show that when the volumetric feed rates were decreased from 8.5 to 5.5ml/min more favorable ion-exchange conditions were achieved, as expected. The effluent solution concentration reached to 5% of its feed concentration (breakthrough points) at t_B=182, 175, 135 min residence times for 5.5, 7and 8.5 ml/min, respectively.

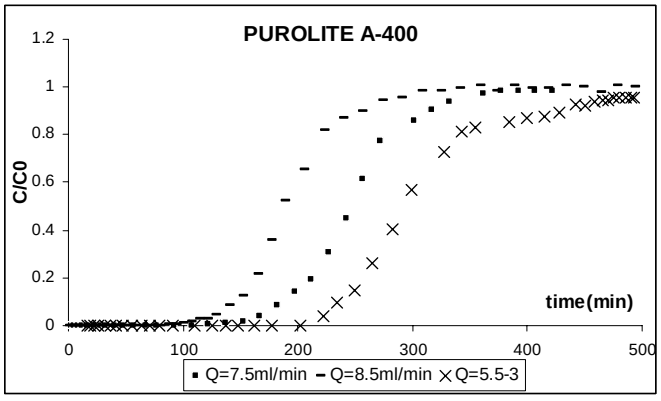

Fig. 1. Effect of flow rates on breakthrough curves by PUROLITE A-400 at 600ppm initial solution concentration of salicylic acid

Volumetric mass transfer coefficients are obtained by the usage of constant wave propagation theory.

In the language of wave propagation theory [11], the introduction of the feed generates a self-sharpening wave. At constant-pattern wave; the ratio of the pollutant concentrations in the stationary and mobile phases is constant [12, 13]:

The constant-pattern wave approach (Eq.1) using the Freundlich isotherm model ($q=kc^n$) fits the experimental breakthrough curves quite successfully.

$$t = t_{1/2} + \frac{\rho k C_F^{\,n-1}}{K_L a}\left[\int_{1/2}^{X} \frac{1}{X - X^{1/n}}\, dX\right] \qquad (1)$$

Where x is the dimensionless effluent concentration, $x=C/C$F, and $t_{0.5}$ is the half-time for x = 0.5. In Eq.1 the parameter $t_{0.5}$ can be directly read from the experimental data and the parameter K_La can be determined from the tangent slope of the x versus t curve.

A correlation was proposed to predict the volumetric mass-transfer coefficient in the liquid phase. The results show that the half breakthrough time decreases inverse proportionally with increasing velocity. The results are shown in Table 1.

Table 1 Effect of feed flow rates on K_La in adsorption of salicylic acid onto PUROLITE A-400

Volumetric feed rate Q (ml/min)	5.5	7	8.5
Volumetric mass transfer coefficient $K_La(min^{-1}$	8 157.20	8 674.10	8 823.50

As the results are shown when the volumetric feed flow rates are increased the volumetric mass transfer coefficients are also increased however before that the result showed that by increasing of feed rates the amount of maximum adsorption or breakthrough point are decreased; so that the system should be worked at optimized flow rates.

4. Conclusion

In this work the adsorption of salicylic acid onto PUROLITE A-400 was investigated. It was found out that strongly-base anion-exchange resin (PUROLITE A400) has satisfied applicability in adsorption of Salicylic acid from aqueous solution.

At equilibrium condition the adsorption isotherms of salicylic acid onto PUROLITE A400 at Langmuire isotherm models fit the entire experimental data well (R^2> 96%).

In addition dynamic studies of salicylic acid adsorption onto PUROLITE A400 was investigated at varying feed flow rates(5.5,7 and 8.5 ml/min).The results showed when the flow rates have been decreased more favorable ion-exchange conditions were achieved. In another language the breakthrough point's time are decreased by the increasing of flow rates.

The constant-pattern wave approach has been used to investigate volumetric mass transfer coefficients for the breakthrough curves of fixed-bed adsorption that it processes with the Freundlich adsorption isotherm. As the results showed volumetric feed flow rates are increased by the increasing of feed flow rates in contrast of the maximum amount of adsorption. So that we should be determined optimize flow rate for the adsorption.

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