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Extraction of Propionic Acid from Aqueous Solution Using Tributyl Phosphate IN Modified Soyabean Oil

Sarvesh Patel[1], Sunderlal Pal[2], Alok Deep[3], Kavita Srivastava[4], Deepak Srivastava[5], Diwakar Z Shende[6], and A K Rathore[7]

1(Department of Chemical Engineering, HBT University, Kanpur)
2(Department of Chemical Engineering, MANIT Bhopal)
3(Department of Chemical Engineering, HBT University, Kanpur)
4(Department of Chemistry, V.S.S.D. College, Kanpur)
5(Department Department of Plastic Technology, HBT University, Kanpur)
6(Department of Chemical Engineering, VNIT Nagpur)
7(Department Department of Chemical Engineering, HBT University, Kanpur)

Abstract:

The experimental studies for extraction of propionic acid using Tributyl Phosphate (TBP) in nontoxic diluent (modified soyabean oil) from aqueous solution have been described here. The extraction equilibrium studies for propionic acid are carried out to find the optimum time of shaking, the effect of temperature and the extraction efficiency (%E). The experimental studies show that extractant (TBP) and diluent influences the extraction of propionic acid. The effect of percentage of TBP in diluent on extraction efficiency has been investigated.

Keywords — **Propionic acid, TBP, Nontoxic diluent.**

I. INTRODUCTION

Propionic acid has principally been produced by chemical synthesis from petroleum feed stock. However, in the past few decades, limited availability of petroleum, excessive industrialization and growing concern for the environment has led to the search for a clean and sustainable technology for the production of propionic acids. Fermentation can be an alternative to the above problems. The fermentation process can compete only with existing petroleum process if a low-cost separation technique is developed. The bottle neck lies in the separation process that accounts for 60-70% of the total production cost due to a large number of separation steps [1].

Reactive extraction involves the formation of reversible complexation product in organic phase by reaction between extractants and the hydrophilic solute like organic acids, bringing a change in the concentration of aqueous phase and thus facilitating a separation. Reactive extraction is much better than the conventional precipitation method as it decreases separation steps and cost. In situ extraction of hydrophilic organic acids can be facilitated by using extractant with nontoxic diluent to prevent the destruction of microorganisms due to toxicity.

A lot of work is done on the reactive extraction of propionic acid [2]-[22] using petroleum-based diluents but very little work is done on using nontoxic diluents such as vegetable oils [23]-[26]. The novelty in the present work is the modification of soyabean oil before use as diluent.

II. .MATERIAL AND METHODS

Tri –n-butyl Phosphate and Propionic acid were purchased from Thomas Baker. The soyabean oil was purchased from the market and was modified before use in the laboratory at CSJM Kanpur. Phenolphthalein was used as an indicator and Oxalic acid was used for standardization. All the chemicals used without any treatment and aqueous solutions were prepared using distilled water

The stock solution of 0.6 gmol/L concentration of aqueous propionic acid was prepared using distilled water. The stock solution was diluted to prepare the solution in the range of concentration from 0.1gmol/L. to 0.5 gmol/L.for extraction.

25 ml of both aqueous and organic phase (without extractant) was shaken for 3 hours (optimum time for shaking) in an orbital shaking incubator at 150 rpm. Phase separation was carried out in a centrifuge (Make: REMI) and the aqueous phase was analyzed for acid content by titration with NaOH. Mass balance was used to determine the amount of acid in the organic phase.

The extraction efficiency (E %) and distribution Coefficient (K_D) was calculated as given below
.
$E\%$= {[HA],in-.[HA],final / [HA],in}*100 (1)

Where,
[HA], in= Initial acid concentration
[HA], final = Initial acid concentration
[HA], org. = acid concentration in organic phase

Few experiments were replicated to check the experimental error and it was found to be ≤3% in the studies.

III. RESULT AND DISCUSSION

3.1 Effect of Shaking Time on extraction:

Time (hrs)	[HA], final (gmol/L)	[HA], org (gmol/L)	Efficiency (%)
1	0.178	0.322	64
2	0.148	0..352	70.
3	0.140	0.362	72.
4	0.134	0.369	73

Table: 1 Variation of extraction efficiency with shaking time at the propionic acid concentration of 0.503gmol/L and 50% TBP in oil at 32 ^{0}C.

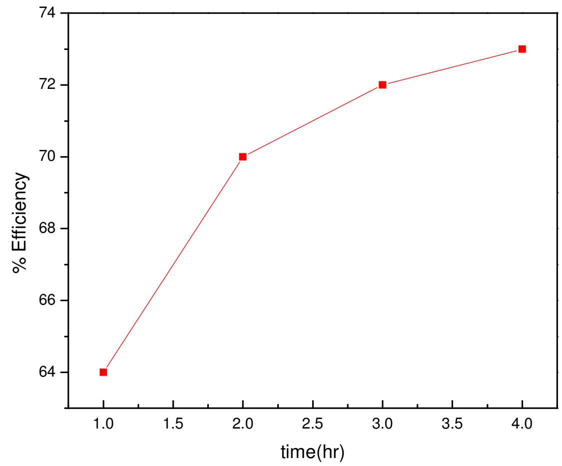

Fig: 1 Variation of extraction efficiency with shaking time at the Propionic acid concentration of 0.503 gmol/L and 50% TBP in oil at 32 ^{0}C.

The effect of shaking time was estimated as it affects the energy requirement and efficiency of the process. The time of shaking in the orbital incubator shaker was varied from 1- 4 hours. The extraction efficiency showed no appreciable change between 3 and 4 hours so 3 hours was taken as the optimum time of shaking. All reactive extraction experiments were then carried out for 3 hours.

3.2 Effect of Temperature on extraction:

TEMPERATURE (^{0}C)	[HA], final (gmol/L)	[HA], org (gmol/L)	E(%)
32	0.103	0.400	79
35	0.116	0.383	76
38	0.140	0.363	72
41	0.156	0.347	69

Table2: Variation of extraction efficiency with the temperature at the propionic acid concentration of 0.503 gmol/Land 50% TBP in oil.

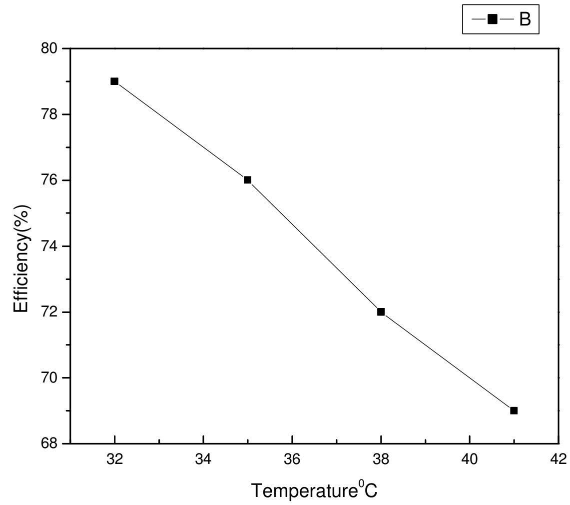

Fig: 2 Variation of extraction efficiency with a temperature at the Propionic acid concentration of 0.503 gmol/L and 50% TBP in oil.

The increase in temperature results in the decrease in extraction efficiency as shown in the figure2.the decrease may be due to following factors such as back extraction of propionic acid, decrease in the value of pK_a values leading to ionization (the extractant TBP only recovers the acid in the unionized state) and mutual solubility's of both the phases increases with temperature. The extraction of organic acids from aqueous phase is reported to be exothermic in nature so extraction efficiency decreases with the increase in temperature i.e the increase in temperature is inversely proportional to extraction efficiency. The results are consistent with the earlier findings [27]-[28].

3.3 Effect of %TBP on extraction:

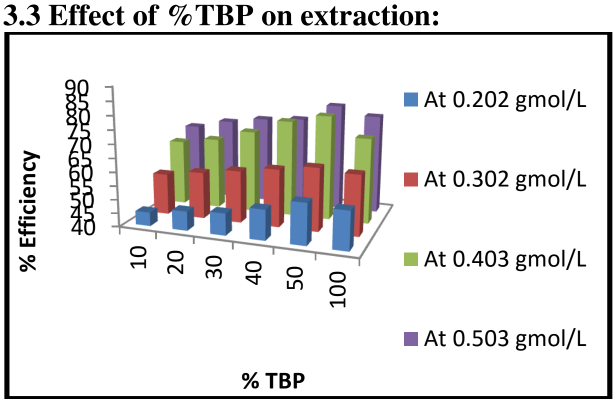

Fig: 3 Variation of extraction efficiency with % TBP in oil for various Propionic acid concentrations.

The figure 3 shows that the extractant TBP plays an important role in extraction. It can be seen clearly that by varying percentage of TBP in oil there is a significant increase in the extraction efficiency. The results also indicate that the oil is capable of solvating the complexation product thus indicating it to be a good diluent for extraction of propionic acid.

The figure 3 also shows that the extraction efficiency increases with the increase in the initial concentration of propionic acid with varying percentages of TBP in oil.

The extraction efficiency of 100% TBP in each case is lower indicating that the high viscosity of TBP is creating hindrance in the extraction process, thus the use of oil as a diluent to modify its flowing characteristics is justified.

CONCLUSIONS

The results showed that the extraction efficiency increases with the increase in TBP Concentration with modified soyabean oil indicating its positive influence on the recovery of propionic acid. The extraction efficiencies were higher than the pure TBP so this will also enable a partial replacement of toxic TBP with ecofriendly oil at enhanced extraction efficiency. More over unlike TBP (small solubility in water) this oil is immiscible with aqueous phase ensuring its recyclability without loss.

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