

## Synergic Transport of Yttrium Metal Ions Through Supported Liquid Membrane

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Synergic transport of metal ions of yttrium has been studied in a supported liquid membrane system using Aliquat-336 and TBP as anion exchange and solvating extractant, respectively. In order to explore synergic transport of yttrium, supported liquid membrane transport of yttrium with single extractant Aliquat-336 or TBP, has been investigated. Possible reactions, occurring at interfaces of source and membrane or membrane and receiving phases during the transport of yttrium metal ions, are proposed. Different experimental variables for these supported liquid membranes explored were stirring speed of source or receiving phase (40 to 140 rpm),  $\text{NH}_4\text{SCN}$  concentration (0.5 to 3 mol  $\text{dm}^{-3}$ ), pH of source phase (0.5 to 5), yttrium metal ion concentration ( $10^{-6}$  to  $2 \times 10^{-2}$  mol  $\text{dm}^{-3}$ ), carrier concentration ( $10^{-5}$  to 0.1 mol  $\text{dm}^{-3}$ ), concentration of complexing agent in receiving phase ( $10^{-6}$  to  $10^{-2}$  mol  $\text{dm}^{-3}$ ), and pH of receiving phase in presence of complexing agent (0.5 to 5). In addition to this, efficiency and stability of investigated supported liquid membrane have been explored.

*Key words:*

Synergic metal ion transport, Aliquat-336, TBP, yttrium, supported liquid membrane, complexing agent

### Introduction

Yttrium plays an important role in several commercial applications. It is an important constituent in phosphoresces, catalyst and super conducting materials. Yttrium behaves similar as lanthanide elements in solvent extraction and separation methods.<sup>1–2</sup> Rare earth elements are associated with yttrium in natural minerals. It is essential to explore new methods for the ion transport behavior of yttrium. In solvent extraction or liquid membrane system with acidic extractants, yttrium behaves like heavy rare earths.<sup>3</sup> However, in nitrate media it behaves like heavy in the extraction process with TBP or Aliquat-336 or mixture of them.<sup>4</sup> Moreover, in thiocyanate media, yttrium behaves like heavy rare earths in extraction with TBP, or mixture of TBP and Aliquat-336 like lighter rare earths with extraction with Aliquat-336.<sup>5</sup> Thus yttrium can be separated from rare earth elements in Aliquat-336-thiocyanate system from lighter once and from heavy lanthanides in the mixture of TBP and Aliquat-336 or TBP or acidic extractants. Such solvent extraction studies have been reported earlier.<sup>6–7</sup> It is very interesting to explore ion transport behavior of yttrium in salt and acid media in supported liquid membrane system. Supported liquid membrane system is an advanced economical viable technique for separation and pre-concentration of several metal ions. Therefore, this paper describes the ion transport behavior of yttrium through supported liquid membrane system

### Experimental

#### Reagents and apparatus

The extractants Aliquat-336 (tricaprylyl monomethyl ammonium chloride or methyl trioctyl ammonium chloride,  $\text{R}^+\text{Cl}^-$ ) and TBP (tri-butyl phosphate) (Aldrich Chemicals Co, USA), were used. The suitable concentration and volume of the extractants over porous supports have been used. Sandwich type supported liquid membranes were used to separate the source and receiving aqueous phases. The suitable concentration of each Aliquat-336 and tri-butyl phosphate was used. The different concentrations of organic solutions were prepared by diluting a desired amount of extractant with kerosene. Metal ion solutions were prepared by dissolving an appropriate quantity of yttrium tri-oxide in hydrochloric acid. The solutions were diluted to 250 ml with distilled water after evaporating the excess acid. The content of metal ion in the solution was confirmed complexometrically at pH 5 with xylenol orange as an indicator. All other chemicals used were of analytical grade.

The experimental apparatus sandwich type cell used during these investigations to measure the permeability coefficient of metal ions is described in Fig. 1. A membrane cell with an interfacial area 11.94  $\text{cm}^2$  was used. The variation of metal ion concentration with respect to time was estimated using samples drawn from the source and receiving solu-

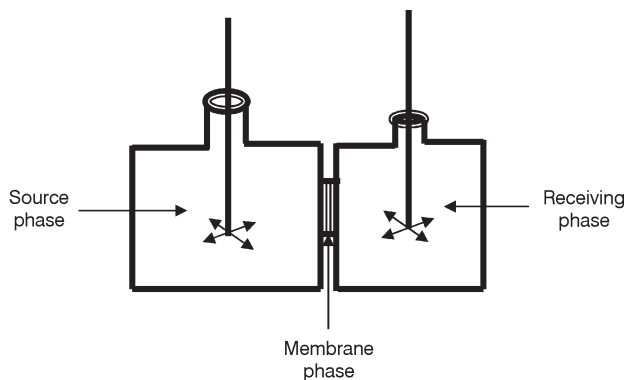


Fig. 1 – Schematic representation of apparatus used for supported liquid membrane system

tions with spectrophotometer at the absorbance at 575 nm after colour development with Arsenazo I indicator at pH 7.5. The reproducibility of the experiment was checked with the experimental results of means of two reproducible runs.

### Preparation of SLM

A membrane sandwich type cell, which is synergic, supported liquid membrane of Aliquat-336, and tributyl phosphate kerosene solution is prepared by impregnation, soaking and removing excess solution by filter paper. The total quantity of containing membrane phase 0.35 ml, source phase 35 ml and receiving phase 25 ml, were used.

### Procedure

A source solution with a suitable metal ion concentration and  $2.5 \text{ mol dm}^{-3}$  ammonium thiocyanate or ammonium nitrate or nitric acid in 35 ml was taken into big cell. Using dilute solutions of hydrochloric acid or sodium hydroxide did its pH adjustment to the desired value. The receiving phase used 25 ml was in small cell with appropriate pH solution. The source and receiving solutions separated by liquid membrane were leak proof. The samples of the source and receiving solutions were pipetted out and the samples were estimated with spectrophotometer at the absorbance at 575 nm after colour development with Arsenazo I indicator at pH 7.5.

## Results and discussion

Separation of yttrium from heavy or lighter lanthanide elements can be achieved using number of solvent extraction stages. In such cases, other practical problems occurred as loading, flooding, and loss of solvent, etc. In supported liquid membrane system, less amount of solvent, continuous operation, suitable design, conveniently number of

stages,<sup>8</sup> easy operation and suitable design, are the added advantages.

A conventional solvent extraction system which is carried out in two steps, either, for separation or pre-concentration of rare earth ions from its source solution, can be illustrated in bulk solutions as shown in Fig. 2. A bulk liquid membrane system, which consists of source (s), membrane (m) and receiving (r) phases, is illustrated in Fig. 2. The extraction and stripping processes are carried out one after the other, after the equilibrium and separation of two phases. However, during these processes, different modes of occurrence involved are dispersion of one phase as drops in another phase, subsequent to coalescence of dispersed phase and phase separation. This mode of operation frequently leads to solvent loss by emulsion formation. This may cause the loss of costly carriers or chelating agents, and extractant loading. The dispersion free solvent extraction technique, i.e. membrane technique eliminates all such shortcomings. Fig. 2 illustrates the transport of trivalent rare earth ions ( $M^{3+}$ ) from source phase through liquid membrane to receiving phase. This ion transport process of metal ion can be represented by two extraction processes, namely, transport of rare earth ion from the aqueous to organic phase as a forward extraction process, and lanthanide ion transport from organic phase to the aqueous phase as a backward extraction process. These extraction processes can be simultaneously carried out in synergic supported liquid membrane extractor as extraction and stripping processes as explored in the present investigations.

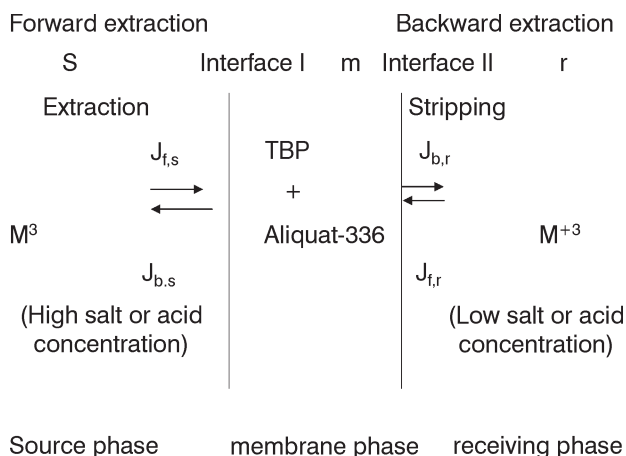


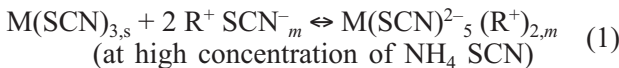
Fig. 2 – Metal ion transport illustration in liquid membrane

### Synergic ion transport mechanism in liquid membrane system

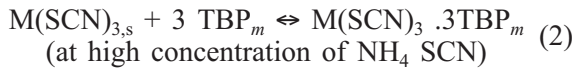
Combination of liquid anion exchanger and solvating solvent in ammonium thiocyanate media is important for the separation of anionic complexes. The combination of liquid anion exchanger

(Aliquat-336, tri-caprylyl mono-methyl ammonium thiocyanate,  $R^+ SCN^-$ ) and solvating extractants, TBP, can be used for the continuous pumping of metal ion from source to receiving phase through liquid membrane phase using salt medium. The liquid anion exchanger is converted into appropriate anion form. The transport of anionic complex of rare earth metal ions with ammonium thiocyanate was explained as follows.

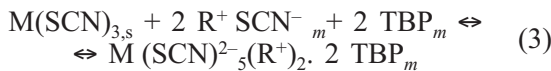
Solvent extraction process occurs with liquid anion exchanger at interface I, the  $R^+ SCN^-$  has high affinity for  $M(SCN)_3$  in thiocyanate medium.



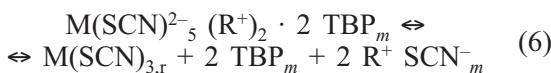
TBP has high affinity towards solvation complex formation with  $M(SCN)_3$  at interface I.



The formation of ion pair and solvated complex with liquid anion exchanger, solvating extractant and  $M(SCN)_3$ , takes place as synergic extractions at interface I as follows.



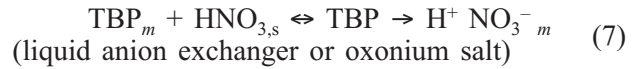
Since, the concentration of ammonium thiocyanate receiving phase at interface II is very low, the dissociation of the formed complexes at the interface II were taking place. The metal salt  $M(SCN)_3$  is transferred from source phase to receiving phase. The released extractants liquid anion exchanger and solvating solvents were diffused to interface I for further transport of  $M(SCN)_3$ . It is given as follows.



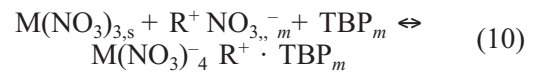
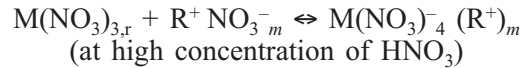
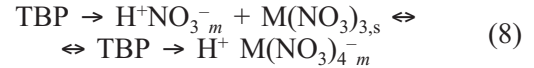
(At low concentration of  $NH_4SCN$  in receiving phase)

Combination of liquid anion exchanger and solvating solvent in nitric acid media is an example to illustrate the important role of acid in ion transport of anionic complexes. The transport of anionic complex of rare earth metal ions in nitric acid media was explained as follows. Solvent extraction process occurs with liquid anion exchanger at interface I. The  $R^+ NO_3^-$  and TBP have high affinity for  $M(NO_3)_3$  in nitric acid medium, the formation of ion pair and solvating complexes were taking place. The synergistic complex is also formed. The liquid anion exchange and adduct formation reactions are

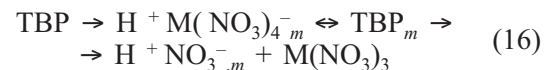
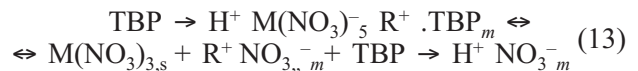
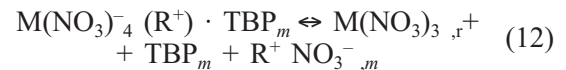
pre-dominant. The formation of oxonium salt takes place at interface I as



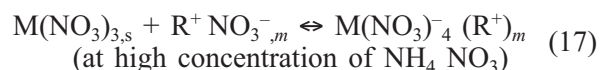
(At high concentration of acid). It acts as a liquid anion exchanger

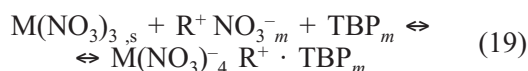


The ion exchange and stripping process took place at interface II.  $M(NO_3)_{-4}^- (R^+)$ ,  $TBP \rightarrow H^+ M(NO_3)_{4-}^-$ ,  $M(NO_3)_3 \cdot TBP_m$ ,  $M(NO_3)_{-4}^- R^+ \cdot TBP_m$  and  $TBP \rightarrow H^+ M(NO_3)_{-5}^- R^+ \cdot TBP_m$  dissociated at interface II because of low concentration of nitric acid in receiving phase. The formed  $R^+ NO_3^-$ ,  $TBP \rightarrow H^+ NO_3^-_m$  and TBP are diffused back for further transport of  $M(NO_3)_3$  at interface I to II.  $M(NO_3)_3$  is released in receiving phase. It is given as follows.

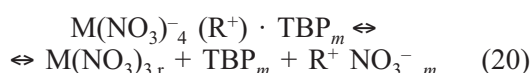


Combination of liquid anion exchanger and solvating solvent in ammonium nitrate media is significant to note that the salt play an important role in ion transport of metal in liquid membrane. The transport of anionic complex of rare earth metal ions in ammonium nitrate media was explained as follows. Solvent extraction process occurs with liquid anion exchanger at interface I. The  $R^+ NO_3^-$  and TBP have high affinity for  $M(NO_3)_3$  in ammonium nitrate medium, the formation of ion pair and solvating complexes occurred. The synergistic complex is also formed.





The ion exchange and stripping process took place at interface II.  $M(NO_3)_4^- (R^+)$ ,  $M(NO_3)_3 \cdot TBP_m$  and  $M(NO_3)_4^- R^+ \cdot TBP_m$  are dissociated at interface II because of low concentration of ammonium nitrate in receiving phase. The complexes were dissociated at interface II, and liberated  $R^+ NO_3^- \cdot m$  and  $TBP_m$  are diffused back to the interface I.  $M(NO_3)_3$  is released to receiving phase at interface II. It is given as follows.



### Effect of the stirring speed

Source and receiving phases were stirred in the range 40 to 140 rpm (Fig. 3). It was observed that the permeability coefficient increased from 40 to 90 rpm and it remained almost same from 90 to 140 rpm. This observation shows that the diffusion layer of ion transport in bulk solutions at interfaces I and II decreases at 40 to 90 rpm speed and it reaches maximum in 90 to 140 rpm. Similar observation was noticed for TBP, Aliquat-336 and mixed TBP+Aliquat-336 systems. Further experiments were done at 100 rpm.

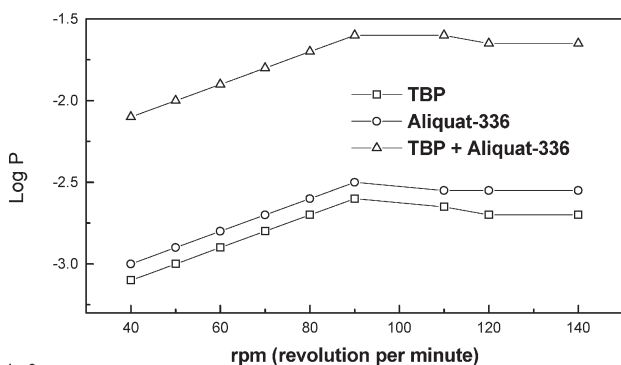


Fig. 3 – The variation of permeability coefficient ( $P$ ) with stirring speed, rpm (revolution per minute), for yttrium,  $c_{Y(III)} = 1 \text{ mmol dm}^{-3}$ ,  $s. p. = 35 \text{ ml } 2.5 \text{ mol dm}^{-3} \text{ NH}_4\text{SCN}$ ,  $r. p. = 25 \text{ ml water}$ ,  $m. p. = 0.35 \text{ ml}$ ,  $pH_s = 5$  and  $A = 11.94 \text{ cm}^2$ , (a)  $TBP = 0.01 \text{ mol dm}^{-3}$ , (b)  $Aliquat(336) = 0.01 \text{ mol dm}^{-3}$  and (c)  $TBP = 0.01 \text{ mol dm}^{-3} + Aliquat-336 = 0.01 \text{ mol dm}^{-3}$

### Effect of ammonium thiocyanate concentration in source phase

Ammonium thiocyanate concentration in source phase was varied from 0.5 to 3 mol  $\text{dm}^{-3}$  for the systems TBP, Aliquat-336 and mixed TBP+Aliquat-336

(Fig. 4a). The results of the permeability coefficient of yttrium ion transport increased with the increase of ammonium thiocyanate for these carrier systems. However, further experiments were carried at 2.5 mol  $\text{dm}^{-3}$  of ammonium thiocyanate.

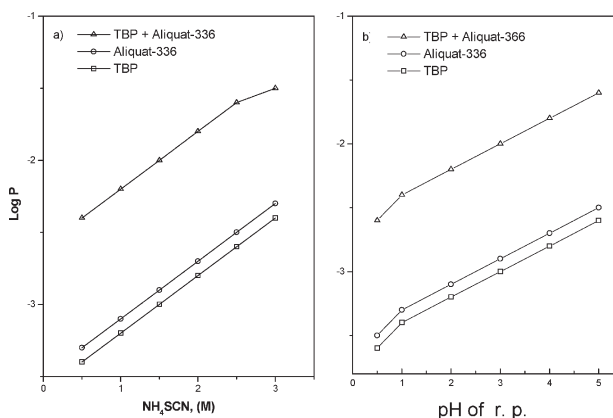


Fig. 4 – The variation of permeability coefficient ( $P$ ) with ammonium thiocyanate concentration in source phase and pH of receiving phase, for yttrium,  $c_{Y(III)} = 0.001 \text{ mol dm}^{-3}$ ,  $s. p. = 35 \text{ ml } 2.5 \text{ mol dm}^{-3} \text{ NH}_4\text{SCN}$ ,  $r. p. = 25 \text{ ml water}$ ,  $m. p. = 0.35 \text{ ml}$ ,  $pH_s = 5$  and  $A = 11.94 \text{ cm}^2$ , (a)  $TBP = 0.01 \text{ mol dm}^{-3}$ , (b)  $Aliquat(336) = 0.01 \text{ mol dm}^{-3}$  and (c)  $TBP = 0.01 \text{ mol dm}^{-3} + Aliquat-336 = 0.01 \text{ mol dm}^{-3}$

### Effect of variation pH of receiving phase

In general, the extraction of metal ion anionic complexes occurs at the higher ammonium thiocyanate concentration in comparison to that of stripping process. In order to strip out the metal ion from membrane phase, it is necessary to reduce active concentration of ammonium thiocyanate and make less competitive to metal ion anionic complex formation during the stripping process towards extractants. Thus, with the decrease in ammonium thiocyanate concentration in receiving solution, the distribution ratio of metal ion decreases at the stripping side. However, to check the pH effect on stripping out the metal ion from membrane phase, the pH of receiving phase was varied in the range 0.5 to 5.0 for the TBP, Aliquat-336 systems. Permeability coefficient for these systems was increased with increase in pH of receiving phase from 0.5 to 5 (Fig. 4b). However, experimental studies are reported of pH 5.

### Effect of yttrium ion concentration in source phase

The variation of metal concentration in source phase for TBP, Aliquat-336 and TBP + Aliquat-336 system was carried out in the range  $10^{-6}$  to  $2 \times 10^{-2}$  mol  $\text{dm}^{-3}$  (Fig.5). The results show the permeability coefficient nearly remains the same at lower concentration range from  $10^{-6}$  to  $10^{-3}$  mol  $\text{dm}^{-3}$ , at the

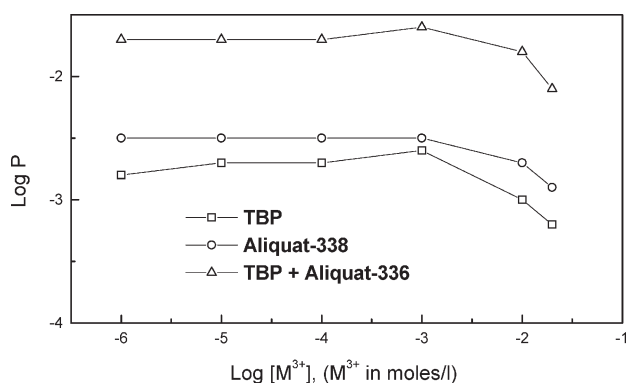


Fig. 5 – The variation of permeability coefficient ( $P$ ) with metal ion concentration for yttrium,  $c_{Y(III)} = 0.001 \text{ mol dm}^{-3}$ ,  $s. p. = 35 \text{ ml } 2.5 \text{ mol dm}^{-3} \text{ NH}_4\text{SCN}$ ,  $r. p. = 25 \text{ ml water}$ ,  $m. p. = 0.35 \text{ ml}$ ,  $pH_s = 5$  and  $A = 11.94 \text{ cm}^2$ , (a)  $\text{TBP} = 0.01 \text{ mol dm}^{-3}$ , (b)  $\text{Aliquat-336} = 0.01 \text{ mol dm}^{-3}$  and (c)  $\text{TBP} = 0.01 \text{ mol dm}^{-3} + \text{Aliquat-336} = 0.01 \text{ mol dm}^{-3}$

above range, it decreases with the increase in the metal ion concentration upto  $2 \times 10^{-2} \text{ mol dm}^{-3}$  studied.

#### Effect of carrier concentration in ammonium thiocyanate media.

Carrier plays an important role in a extractant mediated separation technique. Therefore, the optimization of carrier concentration is an essential. Aliquat-336 concentration variation was carried out from  $10^{-5}$  to  $0.1 \text{ mol dm}^{-3}$  (Fig. 6a). The results show that the permeability coefficient increases with the increase in Aliquat-336 concentration for Aliquat-336 and mixed TBP + Aliquat-336 systems. However, further experiments were done at  $10^{-2} \text{ mol dm}^{-3}$  Aliquat-336. The concentration of TBP was varied from  $10^{-5}$  to  $0.1 \text{ mol dm}^{-3}$  (Fig. 6b). The permeability coefficient was increased with the increase in TBP concentration. However, permeability coefficient values observed are higher for Aliquat-336 and mixed TBP + Aliquat-336 systems in comparison with that of TBP for yttrium.

#### Effect of carrier concentration variation in ammonium nitrate media

Yttrium forms anionic nitrate complex in ammonium nitrate in aqueous phase. Yttrium nitrate salt can be extracted with TBP. Therefore, the transport of yttrium ions through supported liquid membrane has been investigated keeping similar conditions as in the thiocyanate media and varying the concentration of TBP or Aliquat-336 in individual as well as in mixed systems; such studies are reported in figures 6 c-d. In TBP, Aliquat-336 and mixed TBP + Aliquat-336 systems, it is observed that with the increase in carrier concentration, the permeability coefficient increases.

#### Effect of carrier concentration in nitric acid media.

Since yttrium has different characteristics of complex formation in thiocyanate and nitrate, therefore, it is interesting to explore ion transport behavior of yttrium in nitric acid media. Under the similar conditions of thiocyanate media, carrier concentration was varied from  $10^{-5}$  to  $0.1 \text{ M}$  for the TBP, Aliquat-336 and mixed TBP + Aliquat-336 systems (Fig. 6 e-f). It was observed that the permeability coefficient increases with the increase in carrier concentration.

#### Effect of complexing agent concentration in receiving phase

The complexing agent citric acid or tartaric acid or EDTA can be used in receiving phase in order to enhance the permeability of yttrium ions. The concentration variation of citric acid, tartaric acid, and EDTA, was carried out from  $10^{-6}$  to  $10^{-2} \text{ mol dm}^{-3}$  for TBP, Aliquat-336 and mixed TBP + Aliquat-336 systems (Fig. 7 a-c). The results indicate the use of complexing agents in receiving enhances the permeability coefficient with the increase in complexing agent concentration for citric acid, tartaric acid, and EDTA.

#### Effect of pH of receiving phase in presence of complexing agent

Dissociation of complexing agent depends on the pH of aqueous solution hence it has effect on complexation of yttrium ion with citric acid, tartaric acid, and EDTA, with variation of pH of aqueous solution in order to enhance the complexation and conversely it enhance the permeability coefficient of yttrium ion. Thus, the pH of receiving phase in presence of complexing agent for the TBP, Aliquat-336 and mixed TBP + Aliquat-336 was varied from 0.5 to 5. The results show that the permeability coefficient of yttrium increases with the pH from 0.5 to 5 for TBP, Aliquat-336 and mixed TBP + Aliquat-336 systems (Fig. 8 a-c). The effectiveness of complexing agent was found to be in the increasing order tartaric acid < citric acid < EDTA.

#### Pre-concentration of metal ion in thiocyanate media

The pre-concentration of yttrium from source to receiving phase through supported liquid membrane has been investigated in concentration range  $10^{-6}$  to  $10^{-2} \text{ mol dm}^{-3}$  for the TBP, Aliquat-336, and TBP + Aliquat-336 system in thiocyanate media (Fig. 9). Results show that pre-concentration of yttrium metal ions can be effectively achieved from dilute solutions.

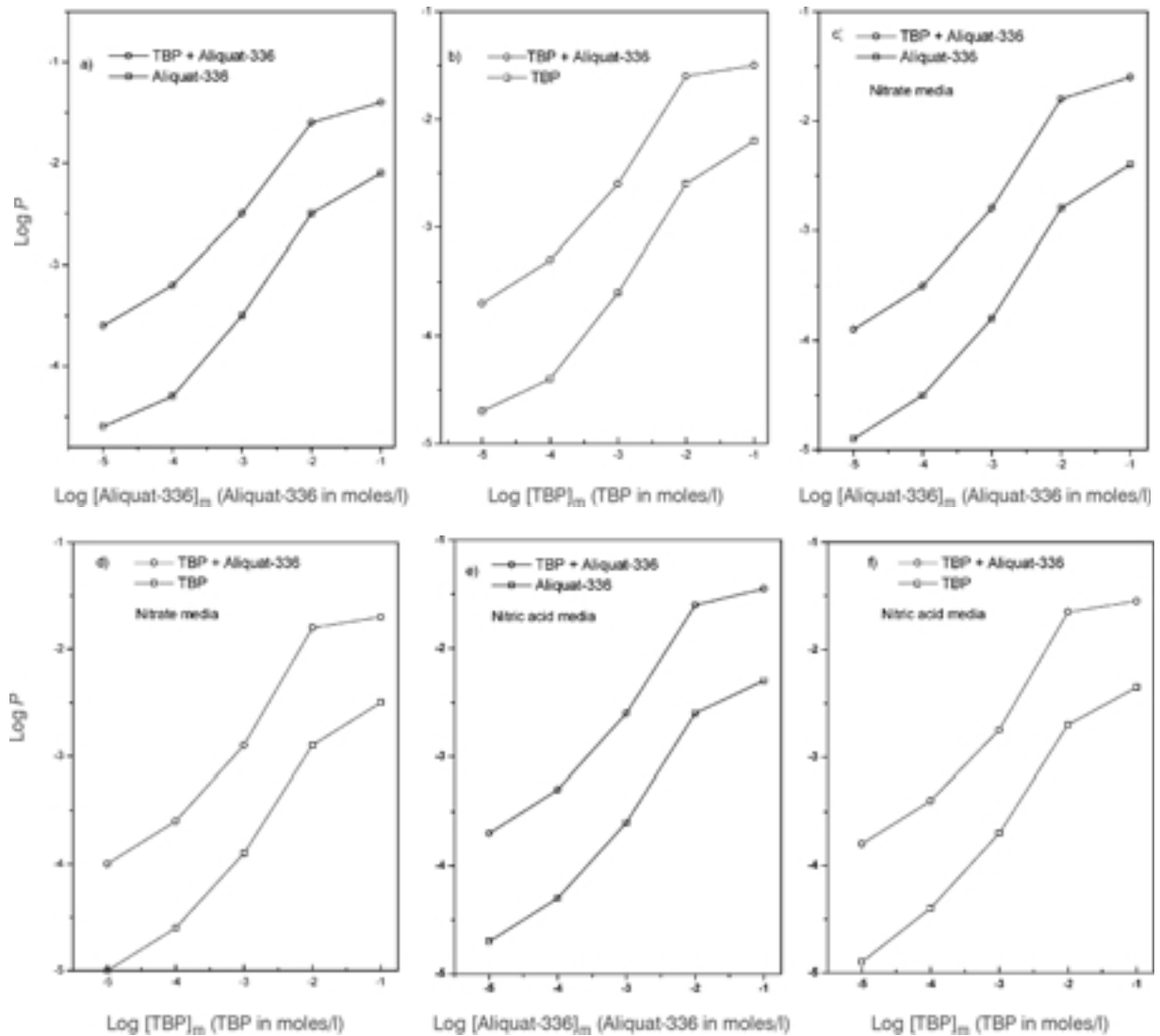


Fig. 6 – The variation of permeability coefficient ( $P$ ) with carrier concentration for yttrium,  $c_{Y(III)} = 0.001 \text{ mol dm}^{-3}$ ,  $s. p. = 35 \text{ ml}$   $2.5 \text{ mol dm}^{-3} \text{ NH}_4\text{SCN}$  or  $2.5 \text{ mol dm}^{-3} \text{ NH}_4\text{SCN}$  or  $2.5 \text{ mol dm}^{-3} \text{ HNO}_3$ ,  $r. p. = 25 \text{ ml}$  water,  $m. p. = 0.35 \text{ ml}$ ,  $pH_s = 5$  and  $A = 11.94 \text{ cm}^2$ ; (a, c and e) TBP = variation and (b, d and f) Aliquat(336) variation

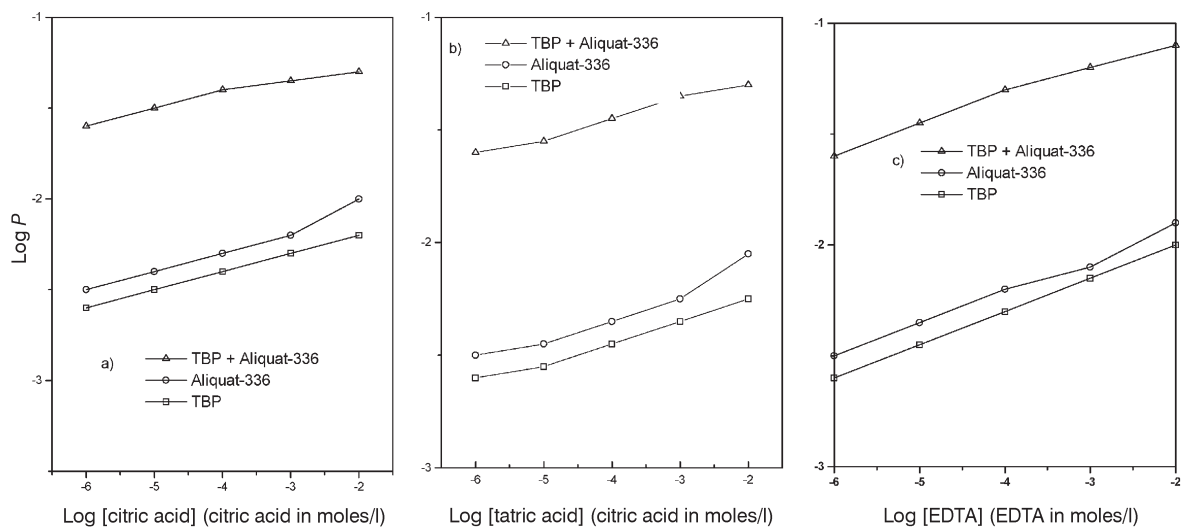


Fig. 7 – The variation of permeability coefficient ( $P$ ) with variation of complexing agent concentration for yttrium,  $c_{Y(III)} = 0.001 \text{ mol dm}^{-3}$ ,  $s. p. = 35 \text{ ml}$   $2.5 \text{ mol dm}^{-3} \text{ NH}_4\text{SCN}$ ,  $r. p. = 25 \text{ ml}$  water,  $m. p. = 0.35 \text{ ml}$ ,  $pH_s = 5$  and  $A = 11.94 \text{ cm}^2$ , TBP =  $0.01 \text{ mol dm}^{-3}$  and Aliquat(336) =  $0.01 \text{ mol dm}^{-3}$ , (a) citric acid, (b) tartaric acid and (c) EDTA

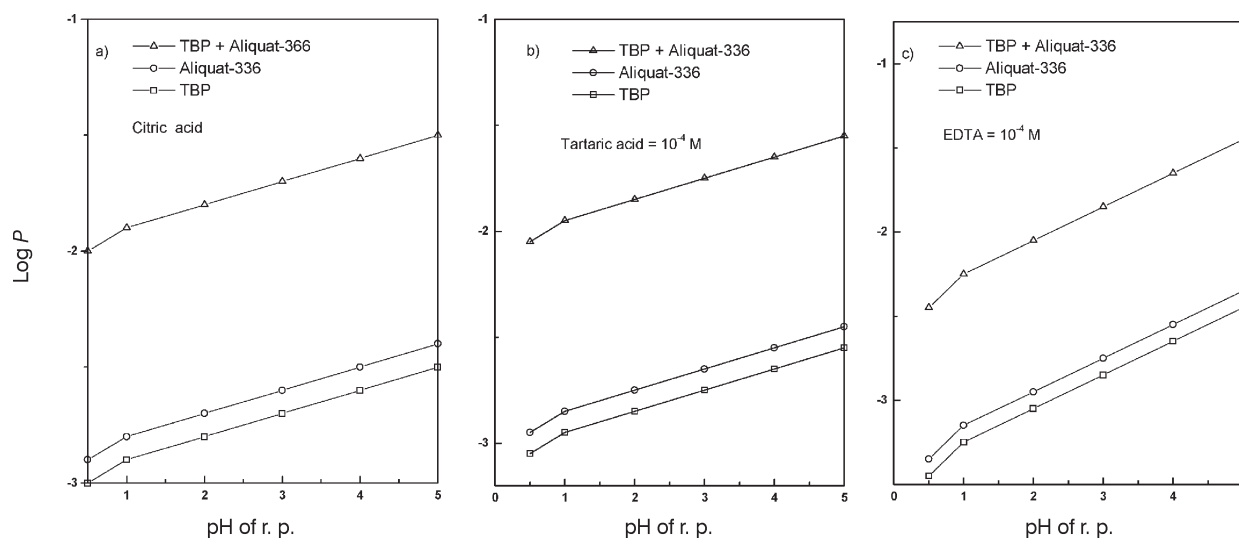


Fig. 8 – The variation of permeability coefficient ( $P$ ) with pH of source phase in presence of complexing agent for yttrium,  $c_{Y(III)} = 0.001 \text{ mol dm}^{-3}$ ,  $s. p. = 35 \text{ ml } 2.5 \text{ mol dm}^{-3} \text{ NH}_4\text{SCN}$ ,  $r. p. = 25 \text{ ml water}$ ,  $m. p. = 0.35 \text{ ml}$ ,  $\text{pH}_s = 5$  and  $A = 11.94 \text{ cm}^2$ ,  $\text{TBP} = 0.01 \text{ mol dm}^{-3}$ ,  $\text{Aliquat}(336) = 0.01 \text{ mol dm}^{-3}$ , (a) citric acid, (b) tartaric acid and (c) EDTA

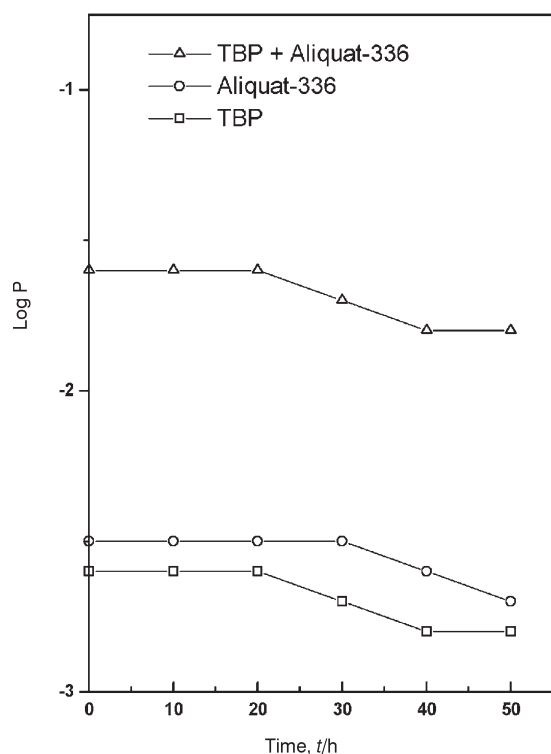


Fig. 10 – The stability constant of supported liquid membrane system for yttrium,  $c_{Y(III)} = 0.001 \text{ mol dm}^{-3}$ ,  $s. p. = 35 \text{ ml } 2.5 \text{ mol dm}^{-3} \text{ NH}_4\text{SCN}$ ,  $r. p. = 25 \text{ ml water}$ ,  $m. p. = 0.35 \text{ ml}$ ,  $\text{pH}_s = 5$  and  $A = 11.94 \text{ cm}^2$ , (a)  $\text{TBP} = 0.01 \text{ mol dm}^{-3}$ , (b)  $\text{Aliquat}(336) = 0.01 \text{ mol dm}^{-3}$  and (c)  $\text{TBP} = 0.01 \text{ mol dm}^{-3} + \text{Aliquat-336} = 0.01 \text{ mol dm}^{-3}$

### Stability of supported liquid membrane

The stability of investigated supported liquid membrane of yttrium has been investigated for TBP, Aliquat-336, and mixed TBP + Aliquat-336 systems for 50 h. The results show that the perme-

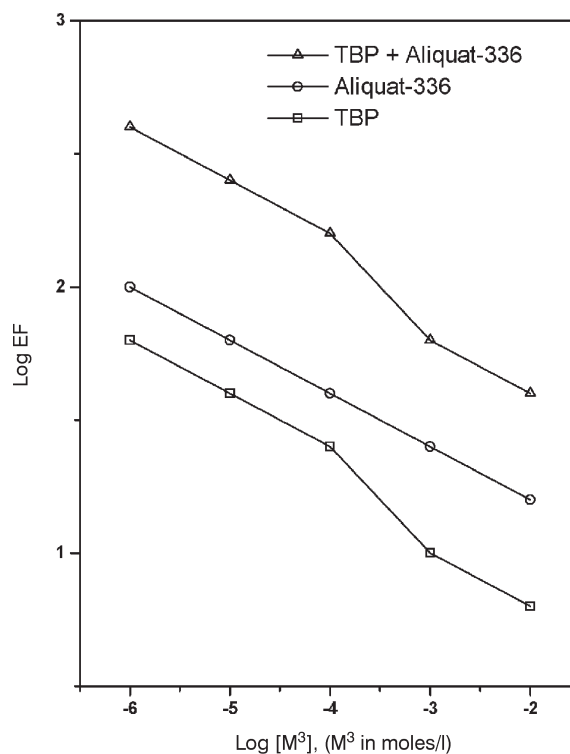


Fig. 9 – The variation of enrichment factor ( $EF$ ) with metal ion concentration for yttrium,  $c_{Y(III)} = 0.001 \text{ mol dm}^{-3}$ ,  $s. p. = 35 \text{ ml } 2.5 \text{ mol dm}^{-3} \text{ NH}_4\text{SCN}$ ,  $r. p. = 25 \text{ ml water}$ ,  $m. p. = 0.35 \text{ ml}$ ,  $\text{pH}_s = 5$  and  $A = 11.94 \text{ cm}^2$ , (a)  $\text{TBP} = 0.01 \text{ mol dm}^{-3}$ , (b)  $\text{Aliquat}(336) = 0.01 \text{ mol dm}^{-3}$  and (c)  $\text{TBP} = 0.01 \text{ mol dm}^{-3} + \text{Aliquat-336} = 0.01 \text{ mol dm}^{-3}$

ability coefficient remains more or less same for 50 h.

Presented experimental data support the developed mechanistic models for the synergic supported liquid membrane system. However, the different supported liquid membrane can be used for the

synergic liquid membrane for the transport metal ion based on ion exchange of anionic complex and solvation. The system can be used for several metal ions in different aqueous media depending on the ability of anionic complex formation and solvation such as in chloride, nitrate, thiocyanate, sulphated, phosphate, organic acids, etc.

## Conclusions

The transport of metal ion in a supported liquid membrane system consisting of source, membrane phase (immobilized on supports with the combination of sandwich type) and receiving phases, has been investigated. Where transport of metal ion is significantly depend on different parameters, such as the ammonium thiocyanate concentration in source solution, carrier concentration, etc. the effect of complexing agents such as citrate, tartarate and EDTA, has been investigated. The effects of these complexing agents have been found efficient in or-

der to pre-concentrate metal ion selectively. The application of developed membrane system has been investigated for the stability of membrane and pre-concentration of metal ion solution from dilute solutions.

## References

1. *Rosick, L., Hala, J.*, J. Radioanal., Chem. **80** (1982) 43.
2. *Warren, C. G., Suttle, J.*, J Inorg. Nucl. Chem., **12** (1960) 336.
3. *Michelsen, O. B., Smutz, M.*, J. Inorg. Nucl. Chem., **33** (1971) 265.
4. *Gaikwad, A. G., Damodaran, A. D.*, J Radioanal. Nucl. Chem. **163** (1992) 277.
5. *Gaikwad, A. G., Damodaran, A. D.*, Anal. Sci. **6** (1990) 768.
6. *Appleton, D. B., Selwood, P. W.*, J. Amer. Chem. Soc. **63** (1941) 2029.
7. *Warren, C. G., Suttle, J. F.* J. Inorg. Nucl. Chem. **12** (1960) 336.
8. *Danesi, P. R.*, Sepn. Sci. And Technol. **19** (1984–85) 857.