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Synthesis of trialkylammonium naphthylacetate IONIC liquid: Its antimicrobial and chromium extraction study

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SYNTHESIS OF TRIALKYLAMMONIUM NAPHTHYLACETATE IONIC LIQUID: ITS ANTIMICROBIAL AND CHROMIUM EXTRACTION STUDY***R. Rama, S. Meenakshi****Department of Chemistry, School of Basic Sciences, Vels Institute of Science, Technology & Advanced Studies (VISTAS), Pallavarm, Chennai-600117, Tamil Nadu, India****Abstract**

A novel Aliquat 336 based functionalized ionic liquid, methyltrioctylammonium naphthylacetate ($[A336]^+[NAA]^-$) have been synthesized and characterized using IR, UV, 1H NMR and Raman spectroscopy techniques. The prepared IL was tested for antimicrobial properties and chromium (VI) extraction. Anti-bacterial test was carried out towards five types of bacteria namely *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus subtilis* and *Salmonella typhi*. The antifungal test was done out towards five types of fungi *Aspergillus niger*, *Trichopyton Spp*, *Penicillin*, *Microsporium gypseum* and *Candida*. $[A336]^+[NAA]^-$ shows inhibitory effect against all the organisms tested. Moreover, $[A336]^+[NAA]^-$ was investigated for the extraction of Cr(VI) as extractant dissolved in a molecular diluent (toluene) and it provides 99.5% extraction of Cr(VI) at pH 3. Stripping of Cr(VI) from loaded ionic liquid phase was carried out using 0.5M NaOH.

Keywords: Ionic liquid, synthesis, antimicrobial activity, Chromium, Extracion.*Corresponding author: Dr. R. Rama (rama.ragu10@gmail.com)

1.0 Introduction

Room temperature ionic liquids (RTILs) have been explored for various applications in electrochemistry, organic synthesis, catalysis, cellulose processing, separation technology and analytical chemistry etc. due to their attractive properties such as negligible vapour pressure, high thermal stability, wide liquid range, high solubility for organic species, wide electrochemical window, tunable properties i.e, the properties of a particular ionic liquid can be changed by changing cation – anion combination, electrical conductivity etc. [1-5] RTILs are organic salts molten at temperatures lower than 100°C. In the recent past, several Aliquat-336 based ionic liquids have been studied for various applications due to their unique and interesting properties. Moreover, Aliquat-336 (quaternary ammonium salt, $[A336]^+[Cl]^-$) is available commercially and inexpensive for preparing a new range of hydrophobic ionic liquids. Several quaternary ammonium ionic liquids have been reported in literature for various applications [6-9]. For example, Voorde *et al.* reported the separation of samarium and europium using a quaternary ammonium nitrate ionic liquid [10]. Arellanes-Lozada *et al.* reported methyltrioctylammonium methyl sulfate (TMA) and trimethyltetradecylammonium methyl sulfate (TTA) ionic liquids as corrosion inhibitors with high inhibition efficiency [11]. Rama *et al.* studied methyltri-*n*-octylammonium bis-(2-ethylhexyl) phosphate ($[A336]^+[DEHP]^-$) for the extraction of actinides [9]. Dasthaiah *et al.* reported the extraction behavior of Am(III) and Eu(III) using methyltri-*n*-octylammonium diglycolamate impregnated Amberlite XAD-7 [12].

Actually, there is an increasing concern about biological issues such as stability, toxicity, biodegradability and recyclability of ionic liquids. In this aspect, the antimicrobial activities of various types of ionic liquids have been reported in literature. For example, Hossain *et al.* reported the antimicrobial property of series of ammonium based ILs and it was noted that secondary ammonium based ILs have higher toxicity than tertiary ammonium

based ILs [13]. Similarly, Saadeh *et al.* reported the antimicrobial property of tetrabutylammonium (TBA) salts: formate, acetate, propionate, butyrate, benzoate, nitrobenzoate, cinnamate, salicylate, sulfanilate, linoleate, and oleate [14]. Ahmad *et al.* reported a new types of cholinium-based ionic liquids and among them choline phenylacetate showed wonderful inhibition of all microorganisms tested [15].

In the recent past, there is a growing need for an assenting action to deal with the environmental pollution due to heavy metal discharge from various industrial effluents. Especially, Chromium pollution is an important concern in chemical industries such as in pigment and paint production, galvanizing, plating, tanning etc [16]. Actually, the transition metal chromium exists in natural samples in two main valence states as Cr(III) and Cr(VI). Trivalent chromium is relatively harmless and plays an essential role in biological processes. However, Cr(VI) species are carcinogenic and toxic. Under the alkaline to slightly acidic conditions, the toxic hexavalent chromium anions such as chromate (CrO_4^{2-}), bichromate (HCrO_4^-) and dichromate ($\text{Cr}_2\text{O}_7^{2-}$) are not strongly sorbed in many soils. Thus, they can be very mobile in subsurface environment and results in toxic effects on biological systems. The major toxic effects of Cr(VI) are corrosive reaction in nasal septum, chronic ulcers, dermatitis and local effects in the lung. Hence, an effective technology is needed for the removal of the Cr(VI) and in this aspect research works are being carried out worldwide.

Various methods have been reported for the removal of Cr(VI). Especially, ion-exchange, solvent extraction, liquid membrane, electrochemical methods and adsorption are highly useful in the recovery of chromium [17-19]. Moreover, in the recent past, there have been growing research activities on removal of chromium using room temperature ionic liquids (RTILs) due to the fascinating properties of RTILs [20 - 22].

In the present study, a novel Aliquat-336 (methyltrioctylammonium) based functionalized ionic liquid (FIL) with strongly coordinating anion namely,

methyltrioctylammonium naphthylacetate ($[A336]^+[NAA]^-$) was synthesized and characterized by IR, UV, 1H NMR, and Raman spectroscopy techniques. The antimicrobial property of the synthesized ionic liquid has been analyzed. Moreover, solvent extraction of Cr (VI) using FIL dissolved in molecular diluent have been studied.

2.0 Experimental

2.1 Materials

All the chemicals and solvents used in the present study were of AR grade. Aliquat 336 (methyltri-*n*-octylammonium chloride) was procured from Fluka (SRL Pvt. Ltd, Chennai). Chloroform, 2-naphthyl acetic acid, diphenyl carbazide and acetic acid were purchased from Sigma Aldrich (Bio corporals, Chennai). Sodium hydroxide was obtained from M/s. S.D Fine Chemicals, Chennai. Potassium dichromate and Toluene was obtained from Srihari chemicals, Chennai.

2.2 Synthesis of methyltrioctylammonium naphthyl acetate ($[A336]^+[NAA]^-$)

The procedure for the synthesis of ionic liquids, $[A336]^+[NAA]^-$ is shown in Figure 1. The first step involved the ion-exchange of chloride ion present in Aliquat-336 ($[A336]^+[Cl]^-$) by hydroxide ion by equilibrating Aliquat-336 in chloroform with 4 M NaOH for one hour. The aqueous phase was removed and the organic phase was equilibrated again with fresh sodium hydroxide. This procedure was repeated at least 8 – 10 times until the Cl^- ion in aqueous and organic phase was negligible (checked with acidified $AgNO_3$ solution) [9]. The solvent (chloroform) was evaporated and the resultant ionic liquid ($[A336]^+[OH]^-$) was dried in a rotary evaporator at 70 °C for about 24 hrs. The second step involved stirring of 2-naphthylacetic acid (NAA) with $[A336]^+[OH]^-$ in 1 : 1. mol ratio for about 48 hr in acetone medium and then the solvent was evaporated. The obtained viscous ionic liquid was washed several times with toluene and then dried in a rotary evaporator at 70 °C for about 24 hrs. Near quantitative yield was obtained.

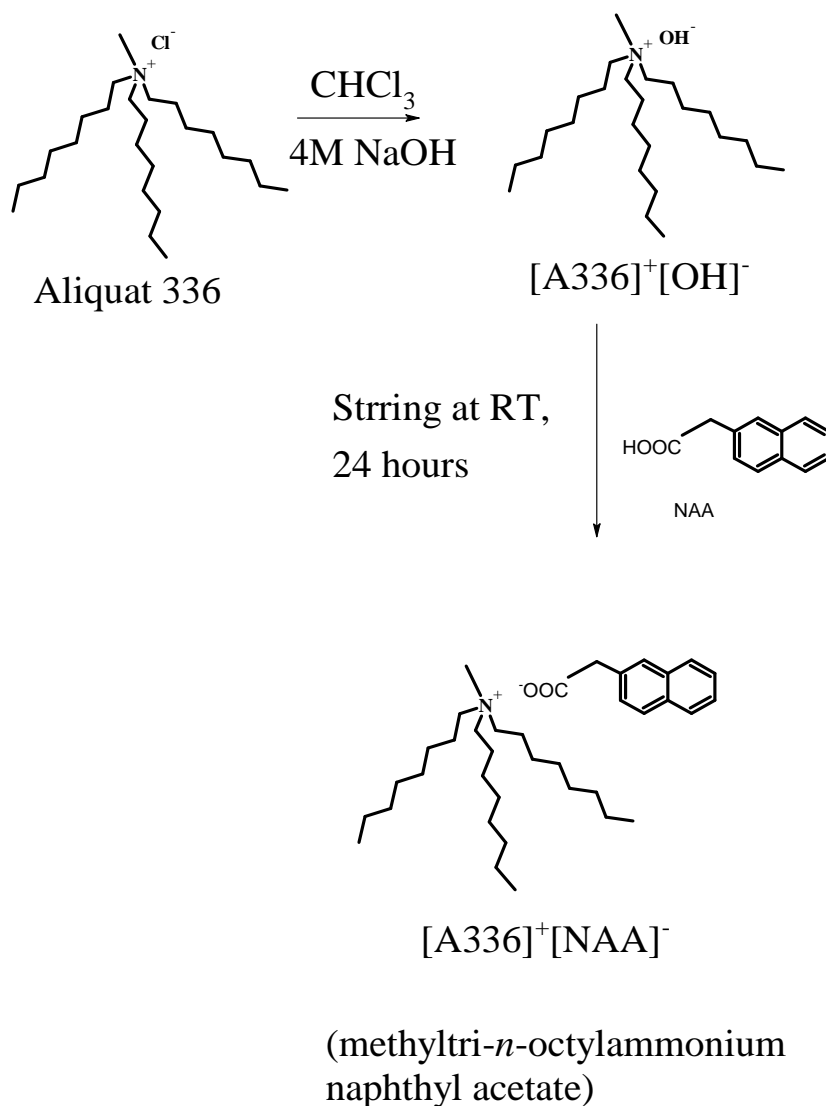


Figure 1. Synthesis of methyltri-octylammonium naphthyl acetate ([A336]⁺[NAA]⁻)

2.3 Antibacterial activity assay

Microorganisms: *Staphylococcus Aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus subtilis* and *Salmonella typhi*. Standard: Ampicillin (20 µl/disc).

Antibacterial activity of extracts was determined by disc diffusion method on Muller Hinton agar (MHA) medium. This medium is poured in to the petriplate. After the medium was solidified, the inoculums were spread on the solid plates with sterile swab moistened with the bacterial suspension. 20 µl of sample (Concentration: 1000 µg, 750 µg and 500 µg) were added in the disc and placed in MHA plates. The plates were incubated at 37 °C for 24

hrs. Then the antimicrobial activity was determined by measuring the diameter of zone of inhibition.

2.4 Antifungal activity assay

Microorganisms: (*Aspergillus niger*; *Trichopyton Spp*; *Penicillin*; *Microsporium gypseum*; and *Candida*). Standard: Amphotericin-B (20 µl/disc).

The disc diffusion method on Potato Dextrose agar (PDA) medium was used to determine the antifungal activity of the sample. PDA medium is poured in to the petriplate. After the medium was solidified, the inoculums were spread on the solid plates with sterile swab moistened with the fungal suspension. Amphotericin-B was taken as positive control. 20 µl each samples and positive control were added in sterile discs and placed in PDA plates. The plates were incubated at 28 °C for 24 hrs. Based on the measurement of diameter of zone of inhibition, the antifungal activity was determined.

2.5 Liquid – liquid extraction studies

All the extraction studies were carried out in triplicate at 298 K unless otherwise mentioned and the results indicate the average of three independent measurements. 0.02 M [A336]⁺[NAA]⁻/ toluene was prepared and it was preequilibrated with desired pH (using HNO₃) solution to fix the equilibrium acidity. The equilibration procedure involved mixing of equal volumes (10 mL each) of ionic liquid phase with desired pH solution containing Cr(VI) (10 ppm) in a 50 ml capacity equilibration bottle immersed in a constant temperature water bath. In all the above experiments, the tubes were rotated in upside down manner for about 2 h. The % extraction was calculated by measuring the concentration of chromium in the organic and aqueous layers. The percentage extraction (E) was calculated using the relation;

$$E = 100D/[D + (V_{aq}/V_{org})]$$

Where, D is the distribution ratio, which is $[Cr]_{org} / [Cr]_{aq}$, and V_{aq} and V_{org} refer to the volume of the aqueous and organic phases, respectively. Cr(VI) was quantified by measuring the concentration in the aqueous phase by spectrophotometric method using standard diphenyl carbazide method at 540 nm. The metal loaded solvent was stripped with NaOH solution to recover the extracted Cr(VI) by equilibrating for 10 min. The % back extraction of Cr(VI) was determined as mentioned above.

3.0 Results and Discussion

3.1 Characterization of methyltrioctylammonium naphthyl acetate ($[A336]^+[NAA]^-$)

3.1.1 FT-IR spectrum: Broad and strong vibrational peaks for C–H stretching of the methylene and methyl units are observed at 2855 and 2925 cm^{-1} . The C-H symmetric deformation was seen at 1370 cm^{-1} . The characteristic peak of C=O stretching of the –COO group present in anionic part of FIL was observed at 1723 cm^{-1} . FT-IR spectra also confirmed this deprotonation by the disappearance of the characteristic –OH broad absorption band of carboxylic acid. The peak at 1465 cm^{-1} corresponds to vibrational peak of CH_2-N^+ group and for phenyl ring peaks were observed at 885 and 785 cm^{-1} . FT-IR spectrum of $[A336]^+[NAA]^-$ is shown figure 2.

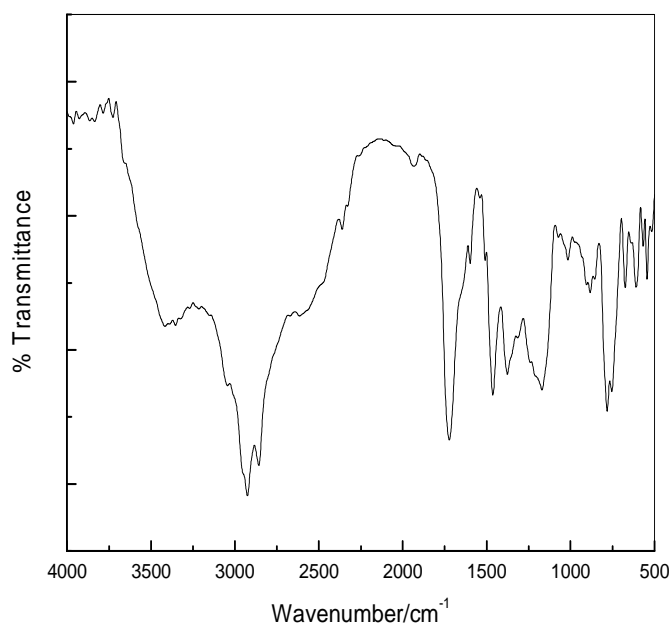


Figure 2. IR spectrum of [A336]⁺[NAA]⁻

3.1.2 UV-Visible spectrum: Absorption between 260 nm and 290 nm reveals the presence of naphthyl acetate anion and aliquat 336 cation. The band gap from absorption spectra of [A336]⁺[NAA]⁻ was found to be 4.41 eV (for $\lambda = 281$ nm, Band gap (E) = $hc/\lambda = hc/281$). UV-Visible spectrum of [A336]⁺[NAA]⁻ is shown figure 3.

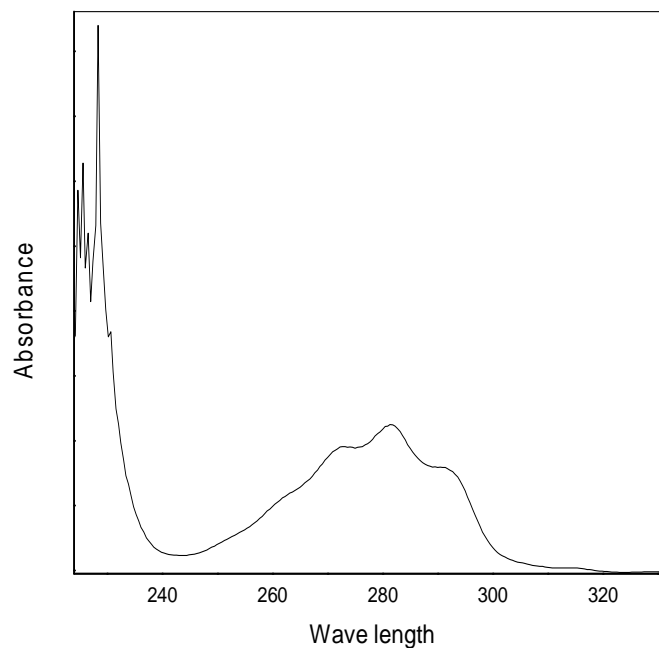


Figure 3. UV spectrum of [A336]⁺[NAA]⁻

3.1.3 Raman spectrum:

A strong band at 2940 cm^{-1} and 3065 cm^{-1} corresponds to $-\text{CH}_2$ and $-\text{CH}=\text{CH}-$ groups respectively. For carboxylate group, moderate bands were observed at 1439 and 1590 cm^{-1} . A characteristic peak for C-H symmetric vibrational frequency was observed at 1384 cm^{-1} . The weak band at 2735 cm^{-1} corresponds to $\text{CH}_3\text{-N}$ group. Raman spectrum of [A336]⁺[NAA]⁻ is shown figure 4.

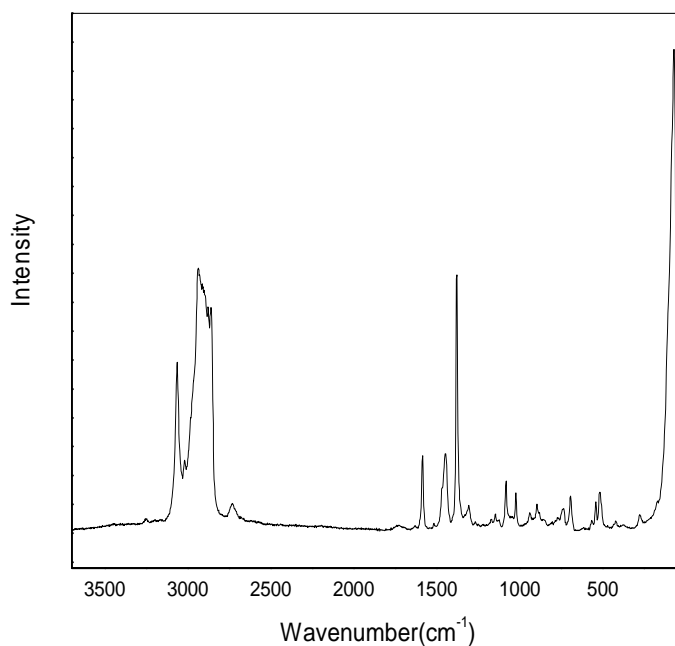


Figure 4. Raman spectrum of $[A336]^+[NAA]^-$

3.1.4 ^1H NMR: 0.863-0.890 (9H, m, $-(\text{CH}_2)_7-\underline{\text{C}}\text{H}_3$), 1.253-1.310 (30H, m, $-\text{CH}_2-\text{CH}_2(\underline{\text{C}}\text{H}_2)_5-\text{CH}_3$), 1.573-1.588 (6H, m, $\text{CH}_2-\underline{\text{C}}\text{H}_2-(\text{CH}_2)_5-\text{CH}_3$), 3.173 (3H, s, $\text{N}-\underline{\text{C}}\text{H}_3$), 3.305 (6H, m, $\underline{\text{C}}\text{H}_2-\text{CH}_2-(\text{CH}_2)_5-\text{CH}_3$), 7.35 – 8.0 (Naphthalene ring) and 4.10 (s, $-\underline{\text{C}}\text{H}_2-\text{COO}^-$). The ^1H NMR spectrum of $[A336]^+[NAA]^-$ is shown in figure 5.

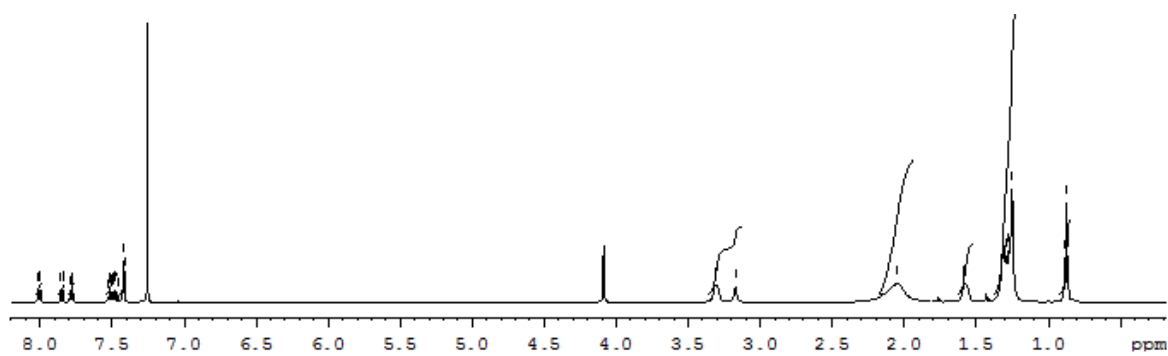


Figure 5. ^1H NMR spectrum of $[A336]^+[NAA]^-$

3.2 Antimicrobial activities of FIL ($[A336]^+[NAA]^-$) using agar disc diffusion method

3.2.1 Antibacterial activity of $[A336]^+[NAA]^-$

The zone of inhibition at synthesized FIL against gram positive and gram negative bacteria is presented in Table 1 and 2 respectively. The figure 6 shows disk diffusion (zone of inhibition) results of *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus subtilis* and *Salmonella typhi* bacteria. $[A336]^+[NAA]^-$ showed relatively good antibacterial activity. Among the gram positive bacteria tested, it was found that the inhibitory effect of *bacillus subtilis* is more as compared to that of *staphylococcus aureus*.

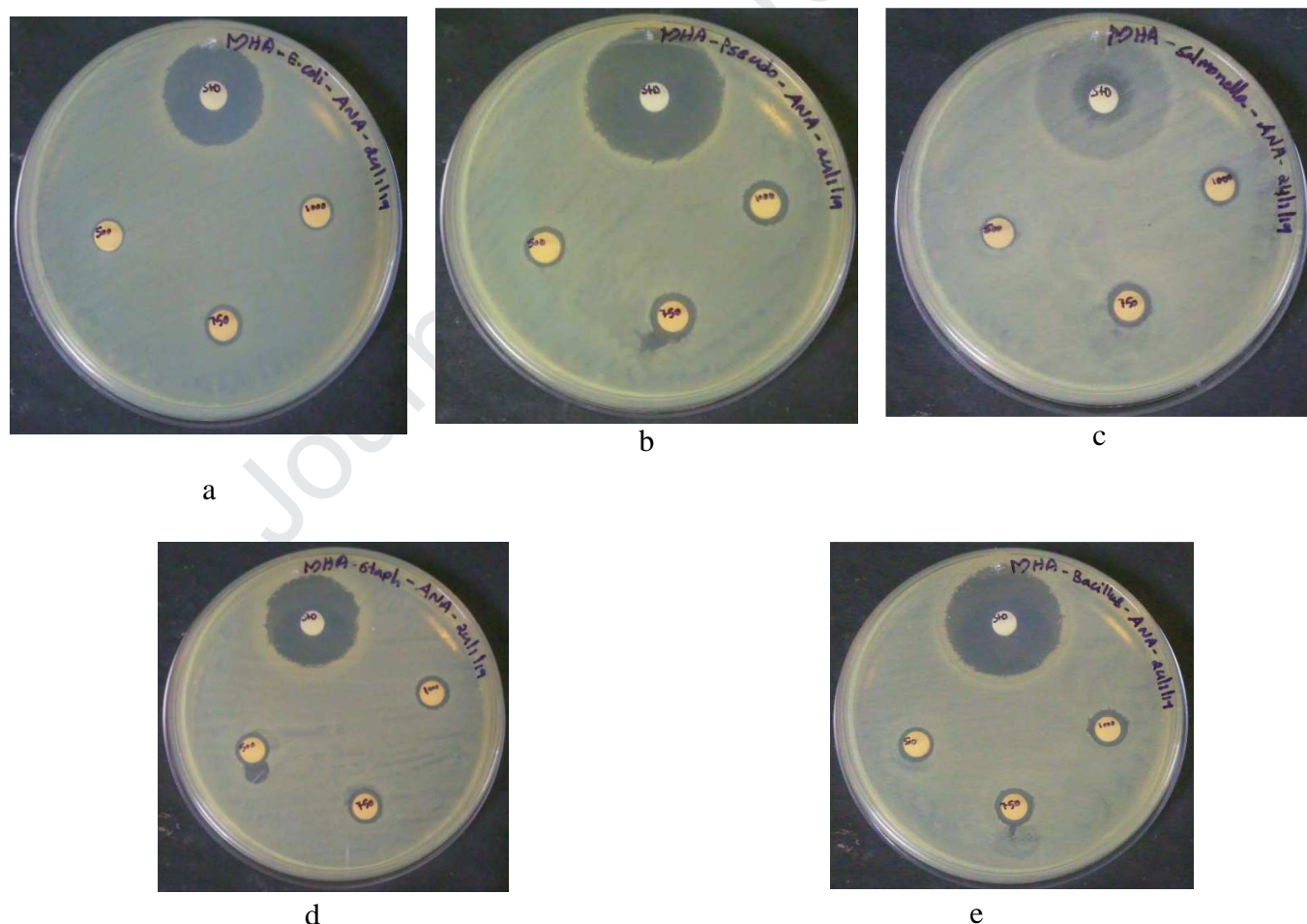


Figure 6. Antibacterial activity of $[A336]^+[NAA]^-$ against gram negative bacteria a). *Escherichia coli*, b). *Pseudomonas aeruginosa* c). *Salmonella typhi* and Antibacterial activity of $[A336]^+[NAA]^-$ against gram positive bacteria d). *Staphylococcus aureus*, e). *Bacillus subtilis*.

The zone of inhibition bacillus subtilis is found to be more than all other bacteria tested at the FIL concentration of 500 µg/ml. But for 1000 µg/ml of FIL, there is a higher inhibitory effect for the gram negative bacteria (*Pseudomonas aeruginosa*). Moreover, in the case of *Bacillus subtilis* (gram positive) and *Salmonella typhi* (Gram negative), the zone of inhibition is constant with respect to the change in concentration of FIL and for the other organisms, it increases after 750µg/ml. The zone of inhibition of *bacillus subtilis* (gram positive bacteria) is found to be more than all other bacteria tested. The reason for this higher inhibition could be attributed due to the presence of hydrophobic alkyl chains in the ionic liquid which can more easily embed into the porous cell of the gram-positive bacteria and disturb the peptidoglycan layer which results in the cell death [23].

Reports on the antimicrobial property of various types of ILs are available in literature [13-15]. For example, recently, Hossain *et al.* [13] reported the antibacterial property of series of ammonium based ILs. In the present study, we have also studied an tertiary ammonium based ionic liquid (methyltrioctylammonium naphthyl acetate [A336]⁺[NAA]⁻) and it has less toxicity than the ammonium ionic liquids reported by Hossain *et al.* Similarly, Salman *et al.* reported the antibacterial property of tetrabutylammonium (TBA) salts (formate, acetate, propionate etc.) [14]. The inhibitory effect of the FIL, methyltrioctylammonium naphthyl acetate against E.Coli bacteria is more than that of TBA acetate.

Table 1: Zone of inhibition of various concentrations of [A336]⁺[NAA]⁻ against gram negative bacteria

Concentration (µg/ml)	Zone of Inhibition (mm)		
	<i>Escherichia coli</i>	<i>Pseudomonas aeruginosa</i>	<i>Salmonella typhi</i>
1000	10	13	10
750	9	11	10
500	9	11	10
Antibiotic (1mg/ml)	23	30	30

Concentration(µg/ml)	Zone of Inhibition (mm)	
	<i>Staphylococcus aureus</i>	<i>Bacillus subtilis</i>
1000	10	12
750	9	12
500	9	12
Antibiotic (1mg/ml)	25	32

Table 2: Zone of inhibition of various concentrations of [A336]⁺[NAA]⁻ against gram positive bacteria

3.2.2 Antifungal property of [A336]⁺[NAA]⁻

The FIL, [A336]⁺[NAA]⁻ was screened for antifungal activity by Agar disc diffusion method using human pathogenic fungal isolates namely *Aspergillus niger*, *Trichopyton Spp*, *Penicillin*, *Microsporium gypseum* and *Candida*. The results are shown in figure 7. The data revealed that significant reduction in growth of fungal strain was brought about by FIL. Among the organisms tested the minimum inhibitory effect of the FIL was seen against *Candida*.

Table 3: Zone of inhibition of various concentrations of [A336]⁺[NAA]⁻ against human pathogenic fungal isolates

Concentration(µg/ml)	Zone of Inhibition (mm)				
	<i>A.niger</i>	<i>Candida</i>	<i>Trichopyton</i>	<i>Penicillin</i>	<i>Microsporium gypseum</i>
1000	16	9	17	15	12
750	14	8	12	13	12

500	14	8	12	12	10
Antibiotic (1mg/ml)	28	12	17	22	13

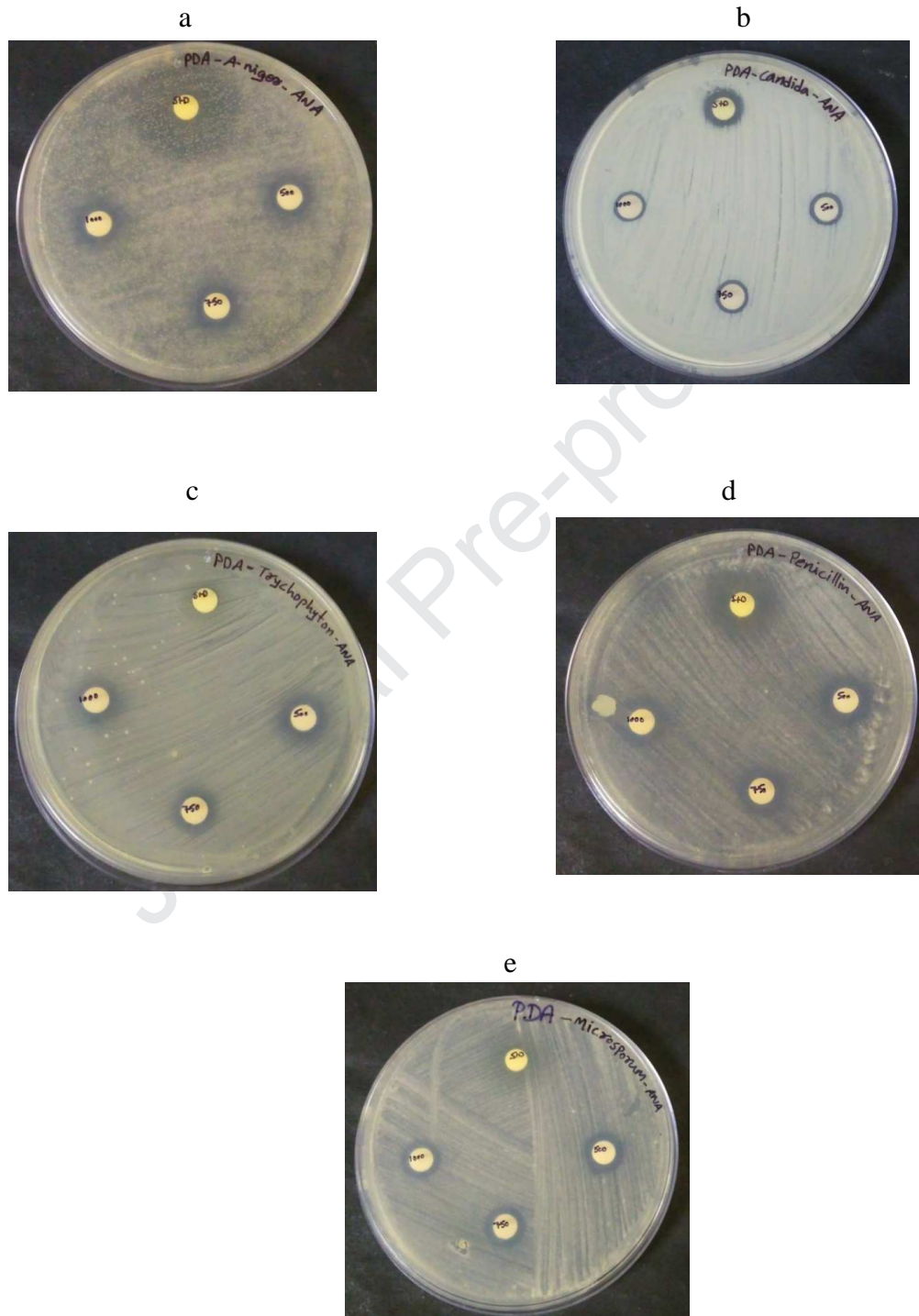
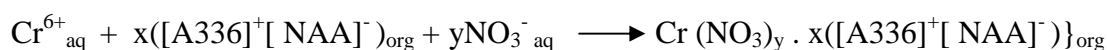


Figure 7. Antifungal activity of [A336]⁺[NAA]⁻ against a). *Aspergillus niger*, b). *Candida* c). *Trichophyton*, d). *Penicillin*, e). *Microsporium gypseum*

3.3 Extraction study of Cr(VI) using [A336]⁺[NAA]⁻/Toluene

Extraction of Cr(VI) was carried out using 0.02 M [A336]⁺[NAA]⁻ /Toluene for various pH range and it is shown in figure 8. The percentage of extraction of Cr(VI) was found to be in the range of 98-99.5%. There are some reports on extraction of Cr(VI) using ionic liquid dissolved in organic solvents. For example, Kalidhasan *et al.* studied the extraction of Cr(VI) using Aliquat 336/ isoamylalcohol and reported 99.5% extraction [14]. P. Venkateswaran *et al.* reported 98% extraction of Cr(VI) in tetrabutylammonium bromide dissolved in dichloromethane [22]. Actually, in the present work, a low concentration (0.02 M) of ionic liquid ([A336]⁺[NAA]⁻) have been used which is comparably less than the concentration of the tetraalkylammonium based ionic liquids (~ 0.12 M) used for the extraction of Cr(VI) in the literature. Even with the less concentration of [A336]⁺[NAA]⁻, the percentage extraction of Cr(VI) obtained in the present study is comparable with that obtained for literature reported tetraalkylammonium based ionic liquid systems. This could be attributed due to the presence of functionalized anion (naphthyl acetate) in IL.

The literature reported mechanism for the metal ion extraction based on bifunctional ionic liquids dissolved in molecular diluents follows the ion association type [6]. Hence in the present study, we believe that Cr(VI) extraction in ([A336]⁺[NAA]⁻)/toluene can be attributed due to the complexation of both cation ([A336]⁺) anion ([NAA]⁻) with the chromium (VI) ion. Moreover, nitrate ion is also considered in the complex to have the charge balance. It can be represented as follows.



The subscripts “aq.” and “org” denote the aqueous and organic phases respectively and x and y are the number of nitrate ions and [A336]⁺[NAA]⁻ ionic liquid involved in the extraction of chromium(VI).

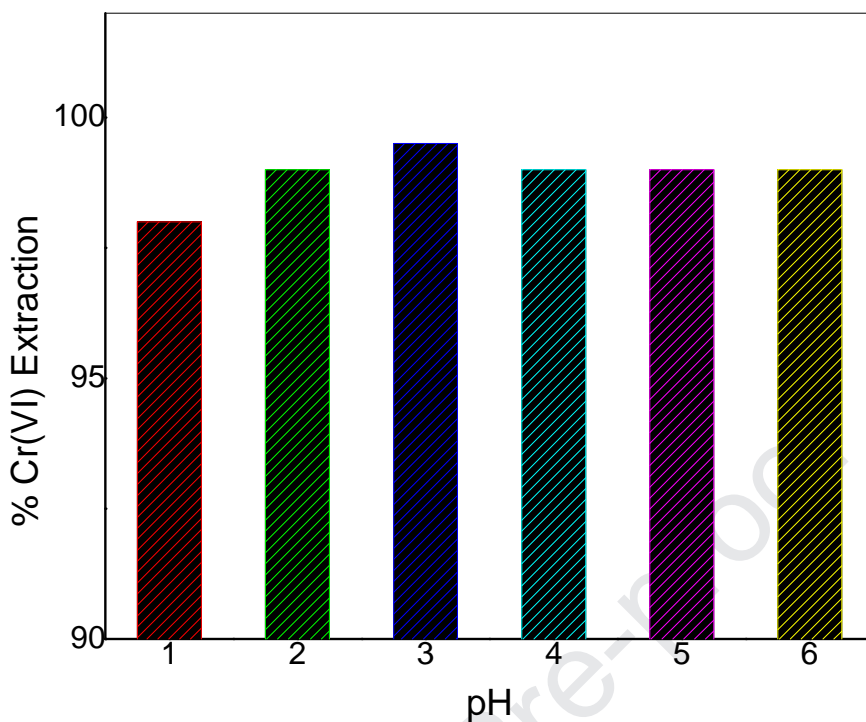


Figure 8. Extraction of Cr(VI) using [A336]⁺[NAA]⁻/Toluene system

3.4 Stripping of Cr(VI) from loaded [A336]⁺[NAA]⁻/Toluene phase

The stripping agents such as NaOH, NaCl and NaNO₃ etc. are reported in literature for the stripping of extracted Cr(VI) from the loaded ionic liquid phase. Moreover, there was a very little loss in volume of ionic liquid and also holds its high extracting ability [22]. Hence in the present study, we have tried to use NaOH to strip the extracted metal ion from the ionic liquid phase. Prior to stripping, the extraction of Cr(VI) was carried out using 0.02 M [A336]⁺[NAA]⁻/Toluene at pH 3. Stripping was performed by contacting the Cr(VI) loaded ionic liquid phase with 0.5 M NaOH and 100 % back extraction of Cr(VI) was achieved using 0.5 M NaOH within 3 contacts. The results suggested that NaOH solution can be used as stripping agent to recover the Cr(VI) from the loaded ionic liquid phase.

4.0 Conclusion

In the present study, a novel Aliquat 336 based functionalized ionic liquid, methyltrioctylammonium naphthylacetate ($[A336]^+[NAA]^-$) have been synthesized and characterized using IR, UV, 1H NMR and Raman spectroscopy. Antibacterial and antifungal activity of $[A336]^+[NAA]^-$ was studied and it shows significant inhibitory effect against all the organisms tested. Moreover, $[A336]^+[NAA]^-$ was investigated for the extraction of Cr(VI) as extractant dissolved in a molecular diluent (Toluene) and it provides >98% extraction of Cr(VI). Quantitative stripping of Cr(VI) from the loaded ionic liquid phase was achieved using NaOH .

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References

- [1]. F. Javed, F. Ullah, M.R. Zakaria, H.M. Akill, An approach to classification and hi-tech applications of room-temperature ionic liquids (RTILs), A review, *J. mol. Liq.* (2018). <https://doi.org/10.1016/j.molliq.2018.09.005>.
- [2]. M. Watanabe, M.L. Thomas, S. Zhang, K. Ueno, T. Yasuda, K. Dokko, K., Application of ionic liquids to energy storage and conversion materials and devices, *Chem. Rev.* 117 (2017) 7190-7239. <https://doi.org/10.1021/acs.chemrev.6b00504>
- [3]. Ji. Chen., Application of ionic liquids on rare earth green separation and utilization, Springer Berlin Heidelberg, 2016.
- [4]. K. Ghandi, A review of ionic liquids, their limits and applications, *Green and sustainable chemistry.* 4 (2014), 44. <http://dx.doi.org/10.4236/gsc.2014.41008>
- [5]. R.L. Vekariya, A review of ionic liquids: Applications towards catalytic organic transformations, *J. mol. Liq.* 227(2017).44-60. <https://doi.org/10.1016/j.molliq.2016.11.123>
- [6]. X. Sun, Y. Ji, F. Hu, Bo. He, Ji. Chen, D. Li, The inner synergic effect of bifunctional ionic liquid extractant for solvent extraction, *Talanta.* 81 (2010) 1877–1883. <https://doi.org/10.1016/j.talanta.2010.03.041>
- [7]. Y. Hua-Ling, W. Wei, C. Hong-Min, C. Ji, Extraction Mechanism of Rare Earths with Bifunctional Ionic Liquids (Bif-ILs) [A336][CA-12]/[A336][CA-100] in Nitrate Medium, *Chin J Anal Chem.* 39 (2011) 1561–1566. <https://doi.org/10.1016/j.talanta.2010.03.041>
- [8]. A. Rout, K.A. Venkatesan, T.G. Srinivasan, P.R. Vasudeva Rao, Ionic liquid extractants in molecular diluents: Extraction behavior of europium (III) in quaternary

- ammonium-based ionic liquids, *Sep. Purif. Technol.* 95 (2012) 26-31.
<https://doi.org/10.1016/j.seppur.2012.04.020>
- [9]. R. Rama, R. Kumaresan, K.A. Venkatesan, M.P. Antony, P.R. Vasudeva Rao, Insights into the extraction behavior of U (VI) in Aliquat-336 based ionic liquids, *Radiochimica Acta.* 102 (2014) 1009-1016. <https://doi.org/10.1515/ract-2013-2228>
- [10]. M. Van de Voorde, K. Van Hecke, K. Binnemans, T. Cardinaels, Separation of samarium and europium by solvent extraction with an undiluted quaternary ammonium ionic liquid: towards high-purity medical samarium-153, *RSC Advances.* 8 (2018) 20077-20086.
[10.1039/C8RA03279C](https://doi.org/10.1039/C8RA03279C).
- [11]. P. Arellanes-Lozada, O. Olivares-Xometl, N.V. Likhanova, I.V. Lijanova, J.R. Vargas-García, R.E. Hernández-Ramírez, Adsorption and performance of ammonium-based ionic liquids as corrosion inhibitors of steel, *J. mol. Liq.* 265 (2018) 151-163.
<https://doi.org/10.1016/j.molliq.2018.04.153>
- [12]. K. Dasthaiah, B.R. Selvan, A.S. Suneesh, K.A. Venkatesan, M.P. Antony, L.R. Gardas, Extraction behavior of Am (III) and Eu (III) by tri-n-octylmethylammonium diglycolamate ionic liquid impregnated XAD-7, *Sep. Sci. Technol.* 52 (2017), 2308-2317.
<https://doi.org/10.1080/01496395.2017.1293688>.
- [13]. M. Hossain, Ajoy Kumer, Synthesis and characterization of ammonium ionic liquids and their antimicrobial and computational overview. *Asian J. Chem. Sci.* (2017) 1-10.
<https://doi.org/10.9734/AJOCS/2017/38877>
- [14]. S.M. Saadeh, Z. Yasseen, F.A. Sharif, H.M.A. Shawish, New room temperature ionic liquids with interesting ecotoxicological and antimicrobial properties. *Ecotoxicology and environmental safety.* 72 (2009) 1805-1809.

- [15]. H. Ahmad, N.S. Zaharudin, N.N.A. Majid, K. Jumbri, M.B.A. Rahman, Synthesis and Characterization of New Choline-Based Ionic Liquids and their Antimicrobial Properties. *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*. 54 (2019).124-132.
- [16]. S.Xia, Z. Song, P. Jeyakumar, S.M. Shaheen, J. Rinklebe, Y.S.Ok, N. Bolan, H. Wang, A critical review on bioremediation technologies for Cr (VI)-contaminated soils and wastewater, *Environ Sci Technol.* (2019) 1-52. <https://doi.org/10.1080/10643389.2018.1564526>
- [17]. M.H. Dehghani, D. Sanaei, I. Ali, A. Bhatnagar, Removal of chromium (VI) from aqueous solution using treated waste newspaper as a low-cost adsorbent: kinetic modeling and isotherm studies. *J. mol. Liq.* 215 (2016) 671-679. <https://doi.org/10.1016/j.molliq.2015.12.057>
- [18]. A. Mohamed, W.S. Nasser, T.A. Osman, M.S. Toprak, M. Muhammed, A. Uheida, Removal of chromium (VI) from aqueous solutions using surface modified composite nanofibers, *J. Colloid. Interf. Sci.* 505 (2017) 682-691. <https://doi.org/10.1016/j.jcis.2017.06.066>
- [19]. K. Mubeena, Muthuraman, Extraction and stripping of Cr (VI) from aqueous solution by solvent extraction, *Desalin water treat.* 55 (2016)2201-2208. <https://doi.org/10.1080/19443994.2014.930697>.
- [20]. A. Nagaraj, M.A. Munusamy, A.A. Al-Arfaj, M. Rajan, Functional Ionic Liquid-Capped Graphene Quantum Dots for Chromium Removal from Chromium Contaminated Water, *J. Chem. Eng. Data.* (2019). <https://doi.org/10.1021/acs.jced.8b00887>
- [21]. A. Nasrollahpour, S.E. Moradi, Hexavalent chromium removal from water by ionic liquid modified metal-organic frameworks adsorbent, *Micropor mesopor mat.* 243 (2017) 47-55. <https://doi.org/10.1016/j.micromeso.2017.02.006>

- [22]. P. Venkateswaran, K. Palanivelu, Solvent extraction of hexavalent chromium with tetrabutyl ammonium bromide from aqueous solution, *Sep. Purif. Technol.* 40 (2004) 279–284.
- [23]. J. Qin, J. Guo, Q. Xu, Z. Zheng, H. Mao, F. Yan, Synthesis of pyrrolidinium-type poly (ionic liquid) membranes for antibacterial applications, *ACS Appl. Mater. Interfaces.* 9 (2017) 10504-10511.

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Highlights

- Synthesis and characterization of Aliquat 336 based functionalized ionic liquid (FIL), methyltrioctylammonium naphthylacetate ($[A336]^+[NAA]^-$).
- Various spectroscopic characterizations including FT-IR, 1H NMR, UV and Raman spectroscopy.
- Antimicrobial studies of FIL
- Solvent extraction of Cr(VI) using $[A336]^+[NAA]^-$ /toluene.

Dr. R.Rama:

Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - Original Draft.

Dr. S.Meenakshi:

Validation, Formal analysis, Investigation

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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