Original Research -investigating viscosity and conductivity of ionic liquids.

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Summary

- Hydrocarbon based solvents are a necessary part of many aspect of the chemical synthesis industry. However their main issue is that they are highly flammable and are often damaging to the environment. We aim to resolve this issue with our research into ionic liquid solvents.

- Our group has decided to investigate the effect alkyl and halide groups on the viscosity and conductivity on imidazolium-derived ionic liquids. This would have practical applications in electrochemistry, catalysis, lubricants in extreme conditions and solvent chemistry.

Research aims

- Synthesise ionic liquids with variance in alkyl and halide groups ie. 1-butyl-3-methylimidazonium bromide
- Prove we have successfully created a new substance ie. No original product within the ionic liquid by thin layer chromatography.
- investigate the effect of halide and alkyl groups on viscosity and conductivity of the ionic liquid.

Methylimidazole + 1-bromobutane -> 1-butyl-3-methylimidizonium bromide

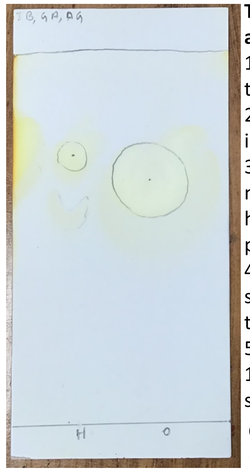
(All ionic liquids used are formed via the reaction above.)

Experimental Method

- reflux apparatus set up.

Synthesis of imidazolium bromide

1. 0.03 mol of 1- methylimidazole are added to a round bottom flask containing 0.03 mol of chosen bromo-alkane and 3-4 anti-bumping granules.
2. The round bottom flask is then fitted with the condenser setup shown.
3. The mixture is heated to 80°C under reflux using a heating mantle
4. Heat for several hours once the mixture has started boiling and reached reflux.
5. Continue to monitor the reflux over this time- the heat should be reduced if the reflux point climbs higher than half way up the condenser otherwise there is a risk of vapours escaping.



- thin layer chromatography of 1-hexylimadizoliumbromide + 1-decylimadizoliumbromide.

Results

Measuring viscosity.

Primary alkyl group (all bromo)	Ave.Viscosity- time taken (s) for a drop to fall 52mm on a 45 degree angle.
Butyl	42.11
Hexyl	281.71
Octyl	322.51
Decyl	477.82

Conclusion.

- There is a positive correlation between viscosity and increased alkyl chain length.
- average viscosity increases as the chain length of the ally group increases while halide group remains constant.
- This is exactly what we predicted would occur as an increased chain length increases the number of electrons in the compound and therefore the number of London forces increases as well as the strength of London intermolecular forces.

Thin layer chromatography using iodine as a stain.

1. Draw a pencil line about 1cm from the bottom of the TLC paper.
2. Place a small drop/sample of each ionic liquid onto the TLC paper
3. Partially fill a beaker with a solvent ie. methanol (be careful not to exceed the hight of the pencil line on the TLC paper)
4. Place the sample TLC paper into the solvent beaker and cover with a glass lid to prevent the solvent evaporating.
5. Wait until the solvent front is around 1cm from the top of the paper, mark solvent front + calculate R.F values.

Conclusion

- From our TLC we can see that all of our ionic liquids were free from impurities apart from that of 1-hexylimadizoliumbromide shown above that does seem to have an impurity so will need to be re purified before further use.

Halide group (All butyl)	Ave.Viscosity- time taken (s) for a drop to fall 52mm on a 45 degree angle.
Chloro	148.64
Bromo	33.69
Iodo	37.07

Conclusion.

- from our results, no trend can be seen between the effect of changing halide group on the average viscosity of the ionic liquid.
- More retesting and analysis will need to be conducted in order to determine the effect of this.
- Although, we can hypothesise that viscosity will decrease down the halide group due to the larger electronegativity of the chlorine group compared to that of Iodine.
- As this was not the results we found, we can assume there was some practical error made or possible impurities in our ionic liquids that will need to be amended before retesting.

Measuring conductivity + Rf values

Primary alkyl group (all bromo)	Conductivity (mSv)	Rf value
Butyl	476.00	0.57
Hexyl	164.27	0.73
Octyl	69.15	0.65
Decyl	25.08	0.49

Halide group (All butyl)	Conductivity (mSv)	Rf value
Chloro	33.84	0.62
Bromo	639.98	0.57
Iodo	496.15	0.61

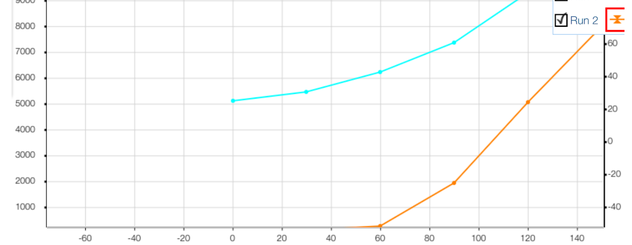
Conclusion

- there is a positive correlation between alkyl chain length and viscosity as, as the alkyl chain length increases; the viscosity decreases.
- It appears that the Rf values are fairly unaffected by changes in alkyl or halide groups. As both sets of data remained almost constant
- Once again there doesn't seem to be an obvious trend in with the addition of varying halide groups suggesting that we mat need to conduct some more testing on these solvents.

Analysis & conclusions

- Synthesis of ionic liquids Is possible in a school environment, suggesting that the process isn't too complex so would be easy to carry out in an industry setting.
- Conductivity of an ionic liquid increases as the temperature increases.

Conductivity and temperature



Future Endeavours.

- Now that we have successfully shown that the synthesis of ionic liquids as solvents is possible outside of an industry setting, we would like to dive further into exploring the practical applications. And work towards developing 'greener solutions' in industry.
- For the future we plan to continue to investigate the use of ionic liquids as catalysts for esterification and look at the effect of changing conditions on value of Kc.
- We may also attempt to make different esters as part of the Greener Fragrances project of IRIS.

References.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7664896/ 07/05/23
https://resourcecentre.researchinschools.org/?projects=ionic-liquids 12/01/23
https://chem.libretexts.org/Courses/SUNY_Oneonta/Chem_221%3A_Organic_Chemistry_I_(Bennett)/2%3ALab_Textbook_(Nichols)/01%3A_General_Techniques/1.04%3A_Heating_and_Cooling_Methods/1.4K%3A_Reflux

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