Do you know what aqueous biphasic systems are? I wouldn't be surprised if you said a layered drinks such as mad dog are an example of such a system, but you would be wrong. Layered drinks and aqueous biphasic systems (ABS) have one thing in common they are composed mainly of water. However if you'd stir the drink it wouldn't separate into those colorful layers, that is why you need to be careful when adding juice. In the case of ABS even after mixing you would observe two separate liquids similarly to know from kitchen olive oil and water mixture. Classical biphasic systems are know from ancient times and are applied in almost all branches of human activity from tasty food and beauty cream to drug preparation. These mixtures are usually composed of water and organic solvent which does not mix with water such as petrol or oil. Characteristic trait of biphasic systems, however rarely observed in everyday life are critical solution temperatures (CST), temperatures at which the solution becomes homogenous (disappearance of two liquids and formation of one liquid). This behavior is reversible. Often we cannot observe CST due to boiling point of one of the mixture components being lower than CST. Known biphasic system in which you can observe CST is ethanol, water and olive oil system, at certain proportions of the mixture.

These mixtures can be used for extraction, meaning separation of one ingredient from a mixture by dissolving in a liquid in which the particular component is more soluble. Usually water and organic solvents are used. However principals of Green Chemistry state that we should not use volatile organic solvents whenever possible due to their toxicity and possibility of environmental contamination. Additionally we should use water as it is the safest solvent. Thus it would be desirable that both liquids used in the extraction would be aqueous liquids, and this where aqueous biphasic systems emerge. In known mixtures of polymers, water and salts we observe separation into two liquids composed mainly of water. One aqueous polymer phase and the other aqueous salt phase. Those systems however exhibit difference in ionic strength (roughly the amount of ion in each phase), which sometimes inhibits extraction process. Solution to this problem is the application of ionic liquids (ILs) instead of polymers or instead of salts. Ionic liquids are a very interesting class of chemical substances. As their name indicates they are mainly build of ions and are liquid around room temperature. Kitchen salt for example is an IL at the temperature of 810○C. This is a very wide class of compounds gathering substances of variety of properties. One that is common to them all is low volatility (they do not evaporate) which is a consequence of their ionic nature. So these compounds fulfill cited green chemistry rules, so naturally they should be combined.

In proposed project I'd like to concentrate on aqueous biphasic systems based on ionic liquids and in particular those systems where we can observe critical solution temperatures near room temperature. These systems would not only enhance extraction processes but could be applied in many more for example enzymatic catalysis.

Research that I'd like to tackle is creation and characterization of new ionic liquids never before studied, as well as those which weren't fully described previously. The challenge in this project lies in creation of moderately hydrophilic (water liking) compounds, because only these compounds will exhibit critical solution temperatures with water. Taking into account that ionic liquids are made out of ions, we can tinker with the ion structures to obtain the ionic liquid of desired properties. One way is to put together two ions of moderate hydrophilicity, the other to take two of different properties one hydrophilic and one hydrophobic (water disliking) in such a way that resulting compound will be of moderate hydrophilicity. To characterize created ionic liquids I'll measure series of properties in aqueous solutions. This data will allow for better understanding of interactions and will allow future researchers for easier designing of ionic liquids of desired hydrophilicity. Aqueous biphasic systems will be made with created ionic liquids to show the possibility of tuning the ionic liquid properties such that critical solution temperatures will be observable. I'd also like to confirm how these systems can be used practically by performing an extraction of few model compounds such as amino acids, dyes or drugs.

I hope that I convinced you that shown research project proposal is interesting not only from theoretical point of view of a chemist, but also from practical of industry.