Toward more efficient CO_2 capture

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Existing methods to capture CO_2 suffer from a series of drawbacks directly affecting their output. Aiming to improve the situation, Dr. Sonia Zulfiqar has been investigating the CO_2 absorption capacity of new materials based on amide polymeric ionic liquids.

Wet scrubbers are currently the preferred option for capturing CO_2 from industrial exhaust streams: they pump polluted air, put it into contact with a scrubbing liquid that attracts carbon dioxide molecules, and finally pumps out the clean air. But more efficient solutions are constantly needed in the face of climate change, and molecular ionic liquids (ILs) are undoubtedly a great candidate.

Since 2014, Dr. Sonia Zulfiqar of the University of the Basque Country in Spain has been focusing on a specific kind of ILs with EU support under the NABPIL (Novel Amide Based Polymeric ionic Liquids: Potential Candidates for CO_2 capture) project. 'Polymeric ionic liquids' (PILs) are not only a potential new member of the CO_2 absorbent family, but they happen to significantly outperform the sorption efficiency of the already highly efficient molecular ionic liquids.

What is the main issue with current CO_2 capture facilities?

While technology already exists to capture CO_2 that encompasses chemical solvent absorption, physical adsorption, cryogenic fractionation, membrane separation, biological fixation as well as the O_2/CO_2 combustion process, existing commercial capture facilities are based on the wet scrubbing process. This process uses aqueous alkanolamine solutions, which often suffer from issues related to corrosion, amine degradation, and solvent losses. This is why new materials for efficient CO2 separation are needed.

In this context, what are the main objectives of NABPIL?

The main goal of NABPIL is the design, production, characterisation and testing of a new class of amide based polymeric ionic liquids that potentially have a high capability of capturing carbon dioxide from natural gas pre-combustion feed and post combustion effluent gases. These novel materials can offer both low cost and high capacity CO2 capture.

With this project, we aimed to push research related to CO2 capture and conversion to new frontiers. Our approach will contribute to the creation of a CO2 economy by introducing efficient ways of capture it before converting into commercial products. These objectives imply the creation of bridges between chemistry, environmental and material sciences.

Why did you decide to investigate ionic liquids rather than other materials? What is their added value?

Materials typically known for CO2 separation processes include silica, activated carbons, zeolites, and metal-organic frameworks. They already have been used with a great degree of success, but there are many issues that still need to be addressed.

We believe the solution to these issues can come from Ionic liquids (ILs), broadly known as 'green solvents'. These are highly versatile materials that have been explored for their outstanding physicochemical properties and applications specifically in CO2 capture and separation. Unlike common organic solvents they boast a negligible vapour pressure, thermal stability and tuneable chemistry.

The functionalisation of polymers featuring ILs chemical groups have led to the development of a new class of polyelectrolytes known as polymeric ionic liquids (PILs) which have been used in the likes of polymer electrolytes for batteries, biosensors, CO2 capture and separation membranes, smart materials, cellulose processing and in gene delivery applications, amongst others.

The use of PILs for gas capture and separation from waste channels—or its storage or transport—is actually the most active and challenging area of PILs research. Their non-volatility, high uptake and reversible sorption of CO2 make them good candidates for environmental applications. PILs bearing amine groups and nanoporous poly(ionic liquid)s versions have been specifically designed with improved CO2 capture. More recently, their permeability and selectivity to other gases including CO2, N2, CH4 and H2 has even been demonstrated.

What are the main difficulties you faced and how did you overcome them?

The proposed scheme was to first prepare amide-based polymers, followed by a quaternisation reaction to produce polymeric ionic liquids. Using this approach, we did not achieve high conversion rate into ionic polymers and the yield was rather low.

To overcome this problem we have tried another strategy that consists in synthesising ionic monomers first and then converting them into ionic polymers. This resulted in a high conversion rate and a better yield.

The project is now completed. Do you have any follow-up plans?

During the execution of the NABPIL project, we have published the first-ever review article highlighting the effect of different parameters on the CO2 uptake performance of PILs. Keeping this in mind, we would now like to incorporate a variety of CO2 philic cations and anions into the ionic polymers and investigate their effect in order to achieve superior CO2 sorption performance.

Did you explore the market potential of your materials yet? If so, what did you find out?

The market potential of these novel materials has not been explored yet . Even though the CO2 sorption capacities of these amide-based PILs are superior to many other PILs, they are still inferior to commercial, non-ionic alternatives.

We are pursuing our efforts to improve the CO2 uptake performance and, once we are happy with the result, we will definitely explore the market potential of these novel PILs.

More information: Project page: cordis.europa.eu/project/rcn/186653_en.html

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