Green-based water lean solvents for CO_2 capture

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The pressing need to reduce anthropogenic CO_2 emissions has intensified research into carbon capture technologies, with solvent-based methods standing out as a practical and scalable option. Conventional amine solvents such as monoethanolamine (MEA) and diethanolamine (DEA) are widely adopted due to their high capture efficiency and industrial maturity. However, these systems are burdened by drawbacks including high energy requirements for regeneration, corrosive behavior, and environmental toxicity.

In light of these limitations, attention has shifted toward bio-based, water-lean solvents derived from renewable sources. These novel alternatives—such as ionic liquids, deep eutectic solvents, and amino acid-based solutions—exhibit favorable properties including low volatility, improved thermal and oxidative stability, and enhanced environmental compatibility. Water-lean bio-based solvents in particular show promise for achieving higher CO_2 absorption capacities with reduced regeneration energy demands.

A comprehensive evaluation of both conventional and bio-based solvents is essential, encompassing not only their technical performance but also their life-cycle environmental footprint. Ultimately, the integration of sustainability criteria into solvent selection and design could enable more balanced and responsible approaches to CO_2 capture.

The objective of the present work is to develop a novel environmentally-sustainable solvent, composed of a bio-based component (i.e., Cyrene), an amine (e.g., MonoEthanolAmine or MEA) and water, able to efficiently remove carbon dioxide from gaseous streams (e.g., flue gas and natural gas). The composition of the most suitable solvent (components and percentages in the mixture) will be addressed through modelling activities, and the final selection will be performed according to performance, sustainability and economic criteria.

Keywords: *water lean solvents, CO_2 capture, modelling, experimental validation*

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