InnoTech Alberta's Phase Changing Solvent

The most widely adopted commercial technology for post-combustion CO2 capture involves chemical absorption using aqueous amine solvents, with mono-ethanol-amine (MEA) serving as the industry benchmark. Although MEA is a well-understood and effective solvent, its application faces significant challenges that undermine the economic and energetic viability of carbon capture projects. The foremost challenge is the immense energy consumption required for solvent regeneration, a necessary process to release the captured CO2 and prepare the solvent for reuse. This regeneration step can account for over 70% of a capture plant's total operating costs. Additional concerns include solvent degradation, equipment corrosion, and solvent losses due to vaporization, all of which contribute to elevated operational costs and the environmental impact of conventional amine scrubbing processes.

To address these challenges, InnoTech Alberta has developed a phase-changing solvent that has the potential to reduce energy demand by over 50% compared to the traditional MEA baseline solvent. When used in conjunction with InfoTech's Microwave technology, energy requirements can be decreased by more than 70%. This innovative solvent aims to further lower energy consumption and transform the conventional design of CO2 capture processes, ultimately leading to reductions in both operational and capital costs.

Phase-change solvents are engineered to capitalize on a thermodynamic principle, where a homogeneous liquid system undergoes a phase transition under specific temperature and CO2 loading conditions. The process begins with a single-phase solvent mixture in the absorber column, where it reacts with CO2 from a gas stream. This reaction converts the solvent into new chemical species. As the concentration of these new species increases with rising CO2 loading, the solvent's physicochemical properties, particularly its polarity and solubility, change. This change ultimately triggers the phase separation into a solid and liquid phase. Traditionally, a crucial element of solvent design has been the formulation and process conditions that avoid any potential phase separation to ensure a robust and efficient solvent circulation process. With the proposed new concept, this limitation is removed, and solvent loading is pushed to its maximum capacity to a point where it triggers the phase-changing behavior. The solid phase can be removed from the absorption process using typical mineral processing equipment, which is well known in the mining and oil sands industry, for thermal regeneration. The novel proprietary microwave stripper designed by InnoTech Alberta is capable of handling solid phase and converting it to CO2 gas and liquid phase, which can be recycled back to the absorption tower.

The absorption process is exothermic, and although the solvent is usually introduced into the absorption tower at a temperature of 40 °C, the temperature within the tower rises to 55-60 °C because of this exothermic reaction. This increase in temperature hinders the loading of CO2 onto the solvent. To address this issue, the proposed concept of incorporating an intercooler into the absorption process aims to enhance solvent loading, thereby promoting greater process intensification and phase separation behavior.

Operational and Environmental Benefits

Phase-change solvents offer several operational and environmental benefits that contribute to a more sustainable and cost-effective CCUS process:

1. Energy Efficiency (more than 70% reduction in energy demand)
2. High Absorption and Cyclic Capacity (at least 30% higher CO2 loading compared to baseline MEA)
3. Improved Kinetics
4. High Desorption Efficiency