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Green Chemistry Made Possible by Carbonated Water

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The pH drop caused by the dissolution of CO_2 in water is greener and easier to reverse than that caused by the addition of conventional acids such as H_2SO_4. This presentation will describe several ways in which this simple phenomenon can be used to further the goals of green chemistry.

We have found that CO_2 in water is a green and effective **acid catalyst**, as a replacement for sulfuric acid in the conversion of cellulose to hydroxymethylfurfural (HMF) and its further conversion to jet fuel. More typical acid catalysts are sulfuric acid or Cr salts.

CO_2 can serve as a **modifier of solution properties**. The physical properties of aqueous solutions change when CO_2 is added at 1 bar, as long as an ionogen is present in the solution. An ionogen can be an amine or a polyamine. The solution density, viscosity, osmotic pressure, and surface tension all change because of changes in the water-ionogen and ionogen-ionogen interactions, as shown by Kirkwood Buff solvation theory.[1] Applications include the purification of recycled wastewater.

Control of suspended particles, including the aggregation, dispersion, and partitioning of particles suspended in water can be controlled by CO_2 if either the water or the particle surfaces or the water contain CO_2-responsive groups. Crystalline nanocellulose particles can be controlled in this manner,[2, 3] which facilitates their purification, use, and transfer between phases.

The ability of CO_2 to **control solute solubility and partitioning** makes it possible to perform liquid chromatography and solid phase extraction in water with little to no need for organic solvents.[4, 5] In addition, one can now make water-based paints in which the polymer binder is fully soluble while the paint is in the can but the polymer binder becomes solid and water-resistant once dried.[6]

Finally, CO_2 in water can reversibly **modify solid surface wettability**. This can be achieved on surfaces including silicon, silica, aluminium, and cotton.

These many capabilities of carbonated water will be described, with an explanation of the guiding principles required for the design of appropriate CO_2-responsive functional groups.[7]

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