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Advanced Polymeric Materials with Exceptional Carbon Dioxide Capture Capacities

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Carbon dioxide (CO_2) emissions resulting from combustion of fossil based fuels increasing the atmospheric CO_2 concentration (currently at 393 ppm) is indubitably an alarming environmental issue such as an irreversible increase in the acidity levels of the oceans. In order to manage current CO_2 emissions, several technologies exist such as chemical solvent absorption, physical adsorption, cryogenic fractionation, membrane separation, biological fixation as well as the oxi-fuel combustion process. Solvent-based absorption technology, especially amine-based solvents, is still the most widely used technique for CO_2 removal in industry. However, it is a known fact that amine based acid gas removal technologies have severe drawbacks to the process such as corrosion, amine recovery and CO_2 uptake capacity. Therefore, in an effort to develop the new possibilities on environmentally friendly and effective CO_2 capturing materials in clean energy applications, we recently synthesized a new class of polymers with high CO_2 adsorption capability termed cyanuric organic polymers (COPs). These compounds do not include metal complexes resulting in a lighter and more stable porous structure that is essential for high CO_2 capture capacity at high pressures.

High accuracy CO_2 adsorption tests were made at pressures up to 200 bars at three isotherms 318 K, 328 K, and 338 K on three COPs called KAIST-1, KAIST-2 and QATAR-1 by using magnetic suspension based sorption apparatus. Moreover, MOF-5 and activated carbon Norit-RB3 were also experimented for comparison purposes since they are well known porous materials used for CO_2 adsorption. Our CO_2 adsorption studies at 318 K revealed a capacity of 127.60 mmol/g (5616 mg/g) for KAIST-1, 47.41 mmol/g (2086 mg/g) for KAIST-2 and 74.86 mmol/g (3294 mg/g) for QATAR-1. In order to put into perspective, KAIST-1 can hold more than five times what dry ice has in CO_2 considering that COPs show modest surface areas.

Here we report robust, inexpensive and reproducible synthesis of cyanuric organic polymers (COPs) with CO_2 adsorption capacities up to 5616 mg/g. To the best of our knowledge, this is the highest CO_2 adsorption capacity to date.