配位不飽和サイトを有する金属有機構造体(MOF)の急速な水吸着・脱着

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Rapid Water Adsorption/Desorption Ability of Metal-Organic Framework with Coordinatively Unsaturated Site

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Metal-organic frameworks (MOFs) are expected for water harvesters and desiccants due to their ultrahigh surface areas and high structural and chemical designability. Although some MOFs have demonstrated distinct water adsorption, the desorption process requires high energy such as high temperature over 60 ºC. Cu-MOF-74 composed of copper ions and 1,4-dioxido-2,5-benzeneicarboxylate has unsaturated coordination sites, showing high adsorption capacity for specific gas molecules. In this study, it was revealed that Cu-MOF-74 desorbed water molecules at 45 ºC and their adsorption-desorption cycles were completed within 30 seconds by alternating humidity to 15 %RH and 5 %RH. FT-IR measurement suggested that water molecules are adsorbed to oxygen atoms of the MOF (carboxylate and phenolate) by hydrogen bonding. It is considered that the high-speed water desorption is led by loose hydrogen bonding between water molecules and Cu-MOF-74. Therefore, Cu-MOF-74 could be expected for water harvesters or desiccants with low energy consumption and high efficiency.
Keywords : Metal-organic framework; Water harvesting; Porous functional material; Unsaturated coordination site; Water resources

金属有機構造体(MOF)は高い比表面積や化学的/構造的デザイン性の高さから大気中からの水回収材料や湿度調整材としての応用が期待される。優れた水吸着能を示すMOFが報告されているが、水の脱着のために60度を超える高温が必要である。銅イオンと1,4-dioxido-2,5-benzenedicarboxylateから成るCu-MOF-74は細孔内に配位不飽和サイトや酸素原子をもち、特定の気体分子に対して高い吸着能を示す。本研究は、Cu-MOF-74が45度で水を脱着し、また湿度をおよそ15 %RHと5 %RHに交互に変化させることで吸着と脱着を30秒で繰り返せることを明らかにした(Fig. 1)。FT-IR測定により、水吸脱着時にMOFのカルボキシレートやフェノレートと相互作用することがわかり、Cu-MOF-74は、細孔中に存在する豊富な酸素原子によって高い水吸着能を示し、水素結合に起因する水分子の緩やかな束縛によって高い脱着能を示したと考えられる。したがって、Cu-MOF-74はエネルギーコストが小さく高効率な水回収材料や湿度調整材としての応用が期待できる。

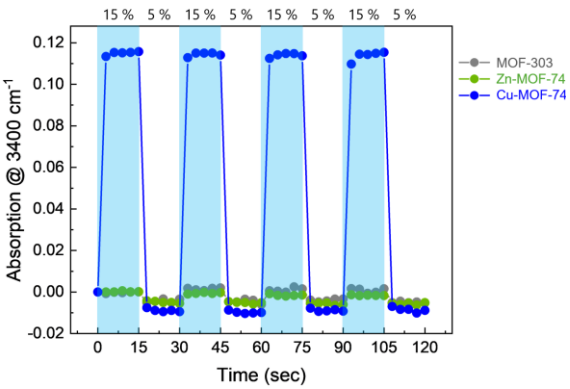

Fig. 1 A change of absorption originated from water upon humidity change for Cu-MOF-74, Zn-MOF-74, and MOF-303 by FT-IR.