Application of Raman Spectroscopy for Sorption Analysis of Functionalized Translucent Materials

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The development of new separation processes and technologies is important both from an economic and environmental perspective as a result of an ever-growing demand for natural resources and high-value compounds. Ionogels are one class of tailor-made translucent adsorbents that have received significant attention due to their potential for high capacity and tuneable selectivity. They are synthesized by incorporating ionic liquids into mesoporous materials such as silica matrices, combining the advantages of both. Silica matrices (e.g., aerogels) offer a large surface area and adsorption capacity but are limited in terms of selectivity. Ionic liquids, on the other hand, are known for their selectivity and tuneability due to the large amount of possible ion pair combinations. However, because of the large number of possible ionogels, an efficient screening process is needed since conventional sorption measurements are typically performed through time-consuming volumetric or gravimetric experiments. A new method based on vibrational spectroscopy could reduce the measurement time significantly. Moreover, optical spectroscopy can be applied to individual particles, which minimizes the required amount of sample and allows the homogeneity of material batches to be determined. Against this background, we present Raman spectroscopy as a new high-pressure tool for the characterization of optically accessible compounds. Here, the sorption capacity of three ionogels was studied with pure carbon dioxide and an equimolar carbon dioxide + hydrogen gas mixture in isothermal experiments. The results show that Raman spectroscopy is a viable tool for quantitative measurements of sorption capacity. This opens the possibility for rapid and direct characterization of gas adsorption by optical means, circumventing the lengthy acquisition times by established measurement techniques. Results were validated through gravimetric sorption measurements at pressures up to 5 MPa with good agreement over the entire pressure range within the combined uncertainties of both techniques.