Azeotropic Fluorocarbon Refrigerant Mixture Separations using Porous Material

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Fluorocarbon refrigerants have been evolving over the past three decades for the purpose of environmental responsibility, performance, and safety. The most widely used fluorocarbon refrigerants today are the hydrofluorocarbon refrigerants (HFCs). Many of these refrigerants are HFC mixtures and are azeotropic in nature. Although HFCs have a zero-ozone depletion potential (ODP), some have relatively high global warming potentials (GWP). As a result, regulations such as the Kigali Agreement propose to regulate the future use of HFC refrigerants in certain applications. The refrigerant industry is therefore currently moving toward the production and marketing of hydrofluoroolefin (HFO) refrigerants and HFO/HFC refrigerant blends due to their lower GWPs.

In order to transition to HFO refrigerants, the millions of kilograms of HFC refrigerants currently in circulation will need to be phased out responsibly. Project EARTH (Environmentally Applied Research Towards Hydrofluorocarbons) focuses on the safe and sustainable recycling of these azeotropic HFC refrigerant mixtures. This project is currently investigating the separation of R-410A, a near-azeotropic refrigerant mixture composed of 50 wt.% HFC-32 (CH_2F_2) and 50 wt.% HFC-125 (CHF_2CF_3). While R-410A itself has a high GWP (2088, relative to CO_2 = 1.0), HFC-32 has a more acceptable GWP of 675 and has the potential to be recycled and reused in refrigerant mixtures with HFOs. The GWP of HFC-125 (3500) is relatively high and must be separated from HFC-32 in order to recycle and reuse it in HFO blends. HFC-125 is a valuable fluorinated feedstock and rather than incinerate it, the refrigerant should be used to produce high-value low-GWP materials.

The use of porous materials is a promising route for performing these challenging separations. Not only are porous materials capable of performing zeotropic, azeotropic, and isomeric separations, but they also provide a more sustainable method for performing these energy-intensive separations. This presentation will cover the progress which has been made in testing the efficacy of porous materials such as zeolites in performing azeotropic HFC refrigerant separations. Adsorption measurements have been performed using a Hiden Isochema XEMIS gravimetric microbalance with HFC-32 and HFC-125 with several types of zeolites. A new XEMIS microbalance utilizing the integral mass balance (IMB) method will be discussed for measuring multicomponent adsorption of R-410A on the same materials. Comparisons of single HFC adsorption isotherms with binary isotherms will be compared and selectivity differences discussed. Heat of adsorption measured with a new Setaram high-pressure calorimeter will be compared with calculated heats of adsorption from microbalance measurements.