The role of polymers in the CO_2 transportation infrastructure: experimental characterization and model analysis

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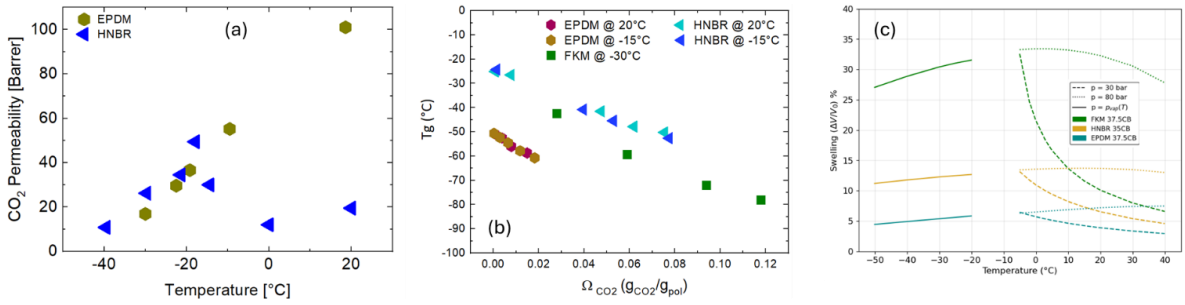
Polymers are versatile materials playing a key role in the safe and efficient transportation of CO_2, an essential stage for the deployment of Carbon Capture and Storage strategies. The lightweight nature, adaptability, and chemical resistance of polymers make them ideal for handling extreme conditions of pressure and temperature typical of CO_2 transport. To that aim, the CO_2 interaction with commercial elastomers is investigated, namely Ethylene Propylene Diene Monomer (EPDM), Viton (FKM) and Hydrogenated Nitrile Butadiene Rubber (HNBR). Their suitability to this application is inspected by dedicated sorption and permeation tests at different T and p, complemented by the assessment of the effect of CO_2 on polymer matrix, evaluating the extent of swelling and plasticization phenomena, together with mechanical and thermal properties. That allows to correlate the properties of the materials with their performances in the carbon transport scenarios.

The CO_2 solubility and permeability at different T and p conditions are examined by an Equation of State approach and by the Standard Transport Model, able to provide an accurate representation of the trends observed. Such model can then be reliably employed to predict CO_2 uptake, swelling and leak rates in any transport scenarios, including liquid or supercritical phases. Furthermore, mechanical and thermal tests indicate that CO_2 uptake impacts the energy storage and glass transition temperature (T_g) by reducing intermolecular interactions and increasing the material free volume, ultimately resulting in the plasticization of the elastomers. High carbon black content in EPDM significantly improves stress resistance and stiffness, while FKM experiences massive swelling given its large CO_2 solubility.

Characterization and modeling efforts provided essential information on the polymers tested, to identify the most suitable grades/materials for a safe and efficient CO_2 transportation operations, an essential stage for the future of sustainable and robust CCS infrastructure.



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