

Gas and vapor transport in dense membranes: outline of recent developments

Ondřej Vopička

Laboratory of Membrane Separation Processes

Department of Physical Chemistry, ICT Prague

Staff:

Milan Šípek, Vladimír Hynek, Karel Friess

PhD students:

Ondřej Vopička, Miroslav Zgažar

vopickao@vscht.cz



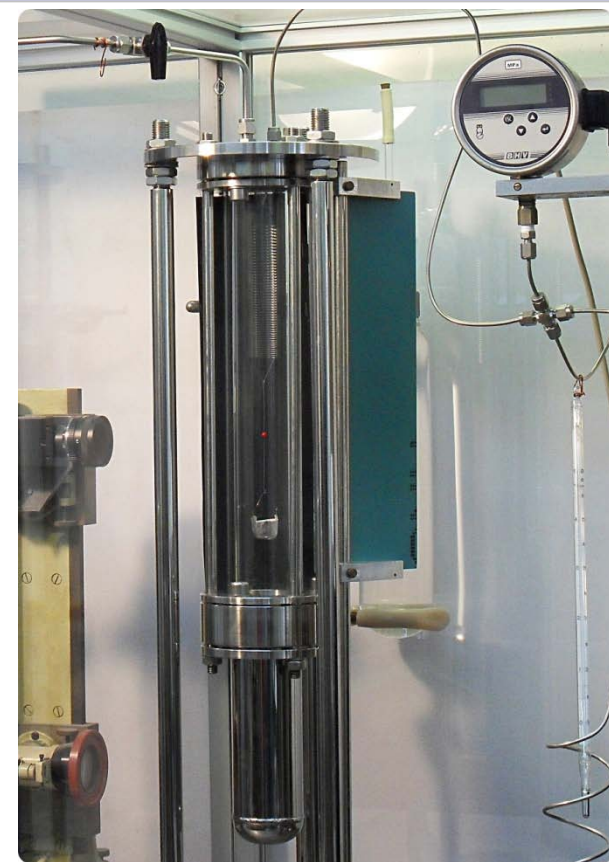
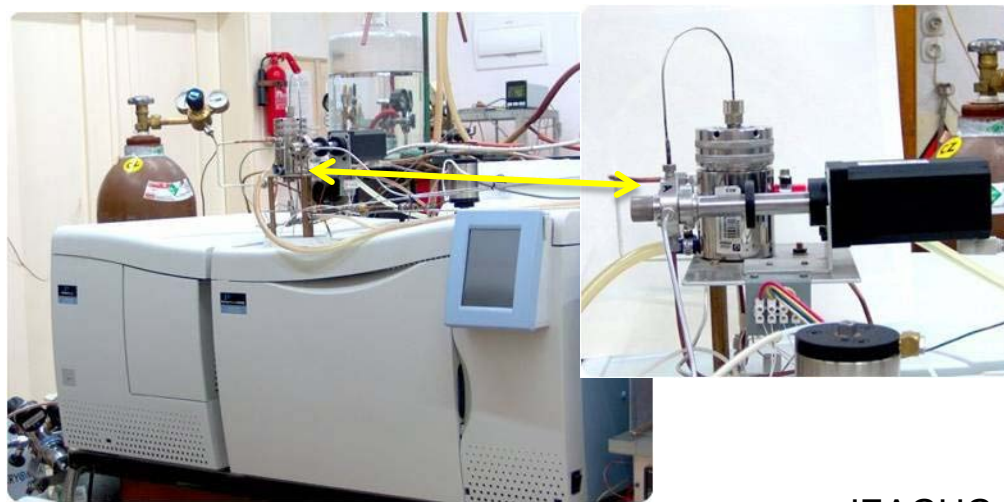
What we do

• Characterization of dense membranes

- Sorption and permeation techniques
 - Vapors and gases
 - Transient and steady-state measurements
 - Modeling of transients, diffusion of mixtures

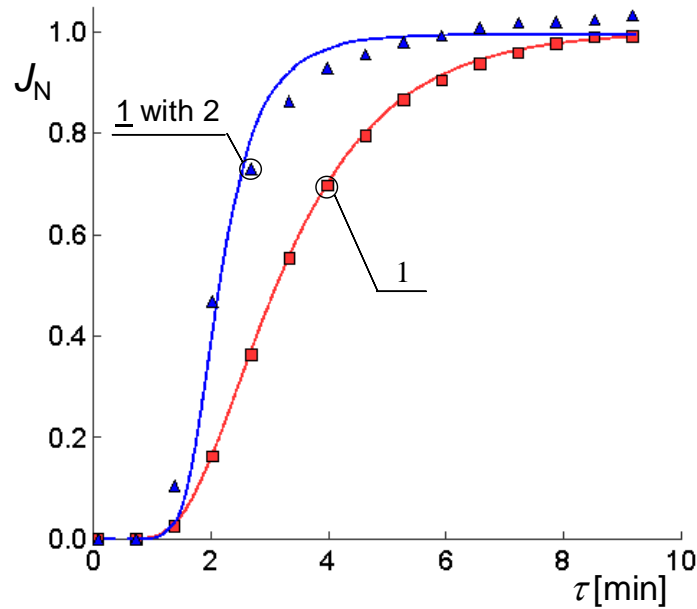
• Novel approaches

- Flow permeameter with fast GC/MS detection
 - Time-resolved compound-specific detection
 - Transient regime permeation of mixtures, coupling effects
- Transient sorption in RTIL-PDMS membranes

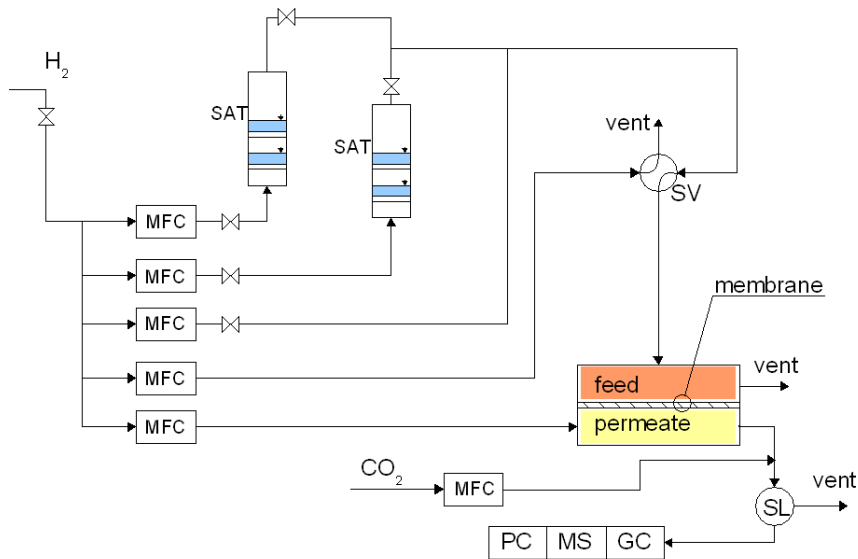
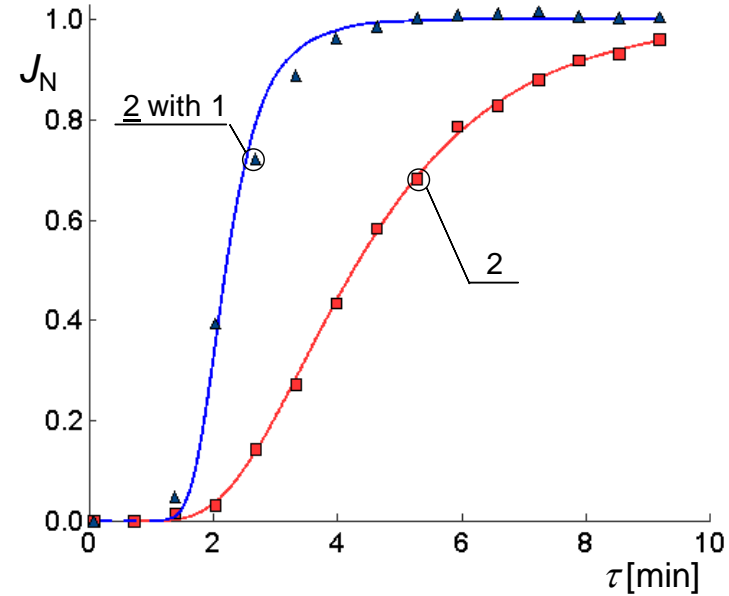


Transient regime permeation of mixtures

p-xylene (1), *p*-xylene with octane (2); LDPE



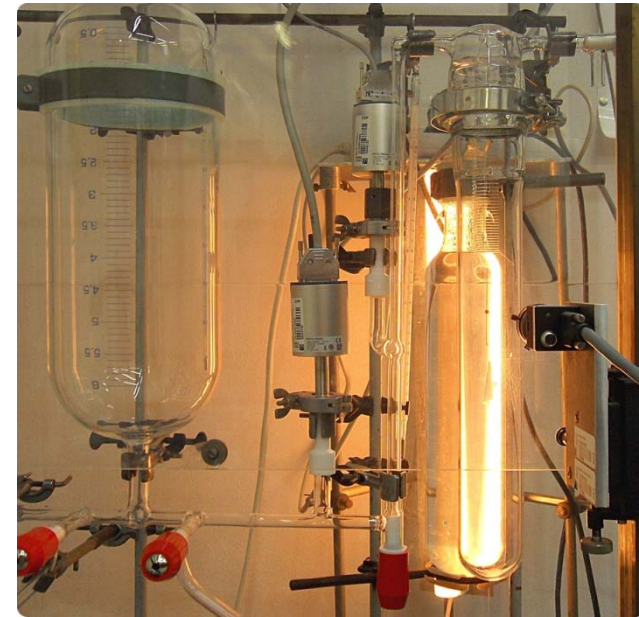
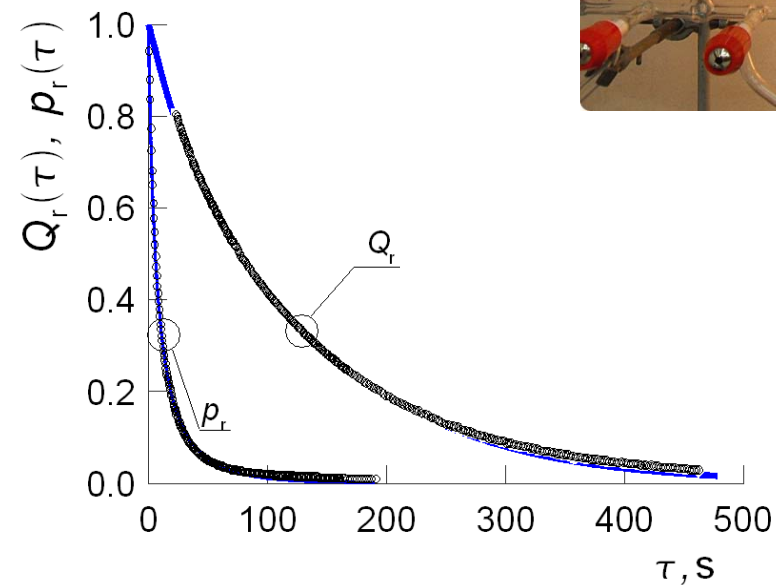
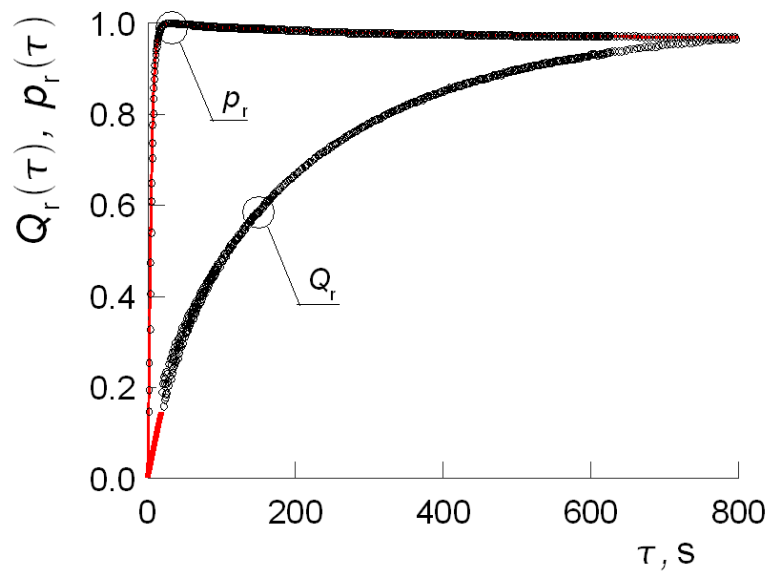
octane (2), octane with *p*-xylene (1); LDPE



O. Vopiřka, V. Hynek, et al., *Journal of Membrane Science* 350 (2010) 217–225

Transient sorption in RTIL-PDMS membranes

- The concept of thermodynamic diffusion coefficient
- Time-dependent boundary conditions
- Gravimetric closed-volume apparatus, Mc Bain's spiral



Running projects

- *Nanocomposite and Nanostructured Polymeric Membranes for Gas and Vapour Separations;*
DoubleNanoMem – the project of European Community's Seventh Framework Programme (FP7/2007–2013) , No. NMP3-SL-2009-228631
- *Separation of fluids by supported ionic liquid membranes;*
Czech Science Foundation, No. 104/08/0600
- *Physico-chemical methods of analysis and characterization of chemical systems and biosystems;*
Czech Ministry of Education, Youth and Sports, No. MSM 6046137307
- *Preparation and Properties of Hyperbranched Polyimide-Silica Combined Materials Usable as Separation Membranes;*
Czech Science Foundation, No. 104/08/0600

Recent publications

O. Vopiřka, V. Hynek, et al., Measuring the transient diffusion of vapor mixtures through dense membranes , J. Membr. Sci. 350 (2010) 217–225

O. Vopiřka, V. Hynek, et al., A new sorption model with a dynamic correction for the determination of diffusion coefficients, J. Membr. Sci. 330 (2010) 51–56

O. Vopiřka, V. Hynek, et al., Blended silicone-ionic liquid membranes: Transport properties of butan-1-ol vapor , Eur. Polym. J. 46 (2010) 123-128

O. Vopiřka, K. Friess, et al., Evaluation of Two Methods for Measuring Vapor Sorption in Polymers, Sep. Sci. Technol. 45(2010) 1260-1264

Equations used

Transient diffusion of mixtures

$$\frac{\partial \phi}{\partial \tau} = (1 - \phi) \cdot \frac{\partial}{\partial x} \left\{ D^0 [\exp(\gamma \phi)] \phi \frac{\partial \ln(a)}{\partial \phi} \frac{\partial \phi}{\partial x} \right\}$$

$$\frac{\partial \phi_1}{\partial \tau} = (1 - \phi_1 - \phi_2) \cdot \frac{\partial}{\partial x} \left\{ D_1^0 [\exp(\gamma_{11} \phi_1 + \gamma_{12} \phi_2)] \phi_1 \frac{\partial \ln(a_1)}{\partial \phi_1} \frac{\partial \phi_1}{\partial x} \right\}$$

$$\frac{\partial \phi_2}{\partial \tau} = (1 - \phi_1 - \phi_2) \cdot \frac{\partial}{\partial x} \left\{ D_2^0 [\exp(\gamma_{22} \phi_2 + \gamma_{21} \phi_1)] \phi_2 \frac{\partial \ln(a_2)}{\partial \phi_2} \frac{\partial \phi_2}{\partial x} \right\}$$

The concept of thermodynamic diffusion coefficient

$$\frac{\partial \phi}{\partial \tau} - \frac{\partial}{\partial x} \left[\underbrace{D_T \phi \frac{\partial \ln a}{\partial \phi}}_{D(\phi)} \cdot \frac{\partial \phi}{\partial x} \right] = 0$$