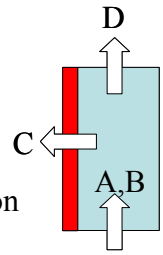
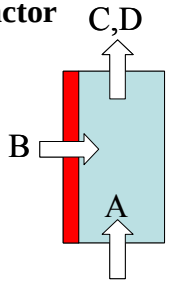
Prof. J. Caro, University of Hannover, Germany

Catalytic Membrane Reactors

Thermodynamically controlled reactions	**Kinetically controlled reactions**
$\Delta_R G^0$ near zero $\Delta_R G^0 = -RT \ln K \rightarrow K \approx 1$ $A + B \leftrightarrows C + D$	$\Delta_R G^0$ very negative $\Delta_R G^0 = -RT \ln K \rightarrow K >> 1$ $A + B \rightarrow C + D$
Extractor type membrane reactor Conversion enhancement: • Dehydrogenation • Esterification • Steam reforming • Knoevenagel condensation • Water splitting	**Distributor type membrane reactor** Selectivity enhancement: Hydrocarbon oxidation p-Xylene oxidation Methane to synthesis gas Partial hydrogenation Methane oxi-coupling



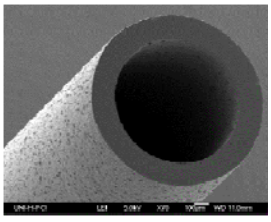


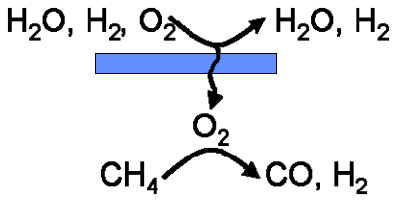
<u>Conversion enhancement</u> in extractor type membrane reactors

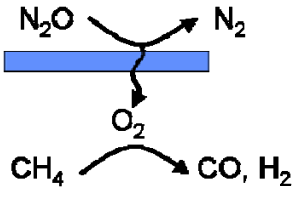
For the thermodynamically controlled reactions, to overcome the equilibrium restriction, the reaction must be sufficient fast compared to the mass transport through the membrane (kinetic compatibility). To this class of reactions belong dehydrogenations of alkanes to the corresponding olefins, esterifications, steam reforming of methane to synthesis gas (CO, H_2), Knoevenagel condensation, thermal water dissociation into H_2 and O_2, and nitrous oxide (N_2O) decomposition to N_2 and O_2.

<u>Selectivity enhancement</u> in distributor/contactor type membrane reactors

In this case, the desired product is usually an intermediate in a consecutive reaction, or is one of the products in a system of parallel reactions. To this class of reactions belong oxidations of hydrocarbons including partial oxidations like the oxidative dehydrogenation of alkanes to olefins and the oxidative coupling of methane to C_{2+} hydrocarbons, the partial oxidation of methane to synthesis gas as well as partial hydrogenations of di- or multi-unsaturated hydrocarbons to less saturated ones.







Perovskite hollow fiber membrane obtained by spinning	Membrane supported water splitting acc. to $H_2O \leftrightarrows H_2 + ½ O_2$	Membrane supported nitrous oxide abatement acc. to $N_2O \rightarrow N_2 + ½ O_2$