Amorphous, turbostratic and crystalline carbon membranes with hydrogen selectivity

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Hydrogen production by catalytic steam reforming of renewable hydrocarbons like bio-methane or bio-ethanol has become an attractive goal of sustainable chemistry. Side reactions as in ethanol steam reforming decrease the hydrogen selectivity. A low-temperature catalytic membrane reactor with a hydrogen-selective membrane is expected to solve this problem. Three different carbon membranes are investigated with respect to their performance to extract hydrogen selectively from the binary and ternary reaction mixtures (H_2/CO_2), ($H_2/CO_2/H_2O$), and (H_2/ethanol) as model systems for bio-ethanol steam reforming. The three carbon membranes under study are (i) an amorphous carbon layer prepared by physical vapour deposition (PVD) of carbon on an porous alumina support using a carbon fibre yarn, (ii) a turbostratic carbon layer obtained by pyrolysis of a supported organic polymer blend as precursor, and (iii) a crystalline carbon prepared by pressing of graphite flakes into a self-supporting disc. For the equimolar binary feed mixture (H_2/CO_2) all carbon membranes were found to be hydrogen selective. For the ternary feed mixture (41 vol.-% H_2/ 41 vol.-% CO_2/ 18 vol.-% H_2O), in the case of the amorphous and crystalline carbon membrane, the hydrogen selectivity remains also in the presence of steam. The turbostratic carbon membrane separates preferentially steam (H_2O) from the ternary feed mixture ($H_2/CO_2/H_2O$).

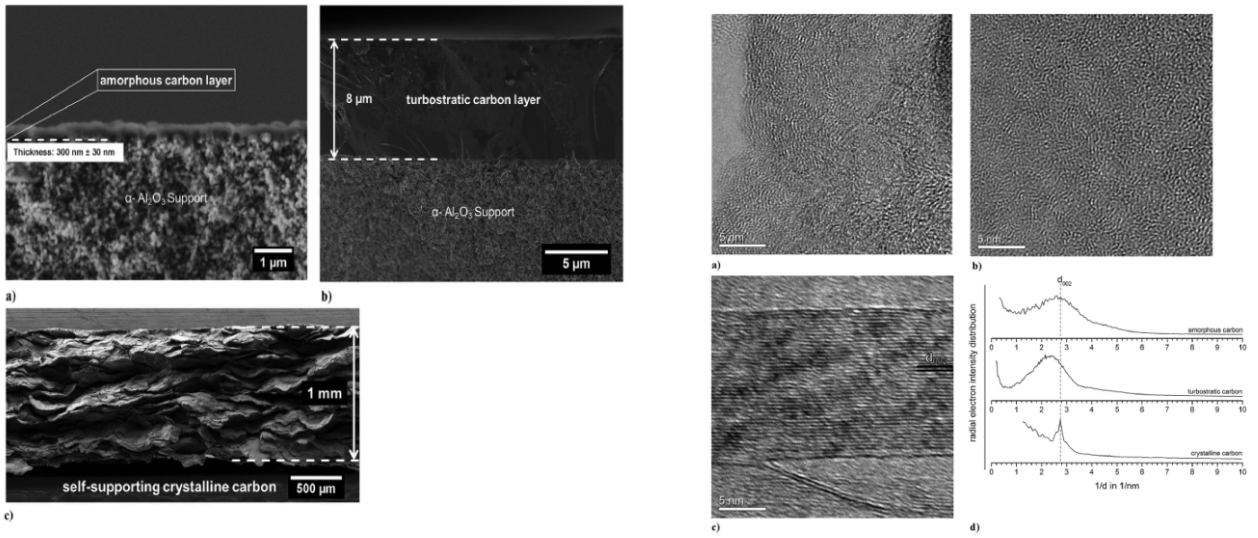

Figure 1 & 2: SEM (Top) and TEM (down) of the three carbon membranes under study: a) Amorphous carbon layer produced by evaporation and condensation, b) turbostratic carbon layer produced by pyroly-sis of a polymer bland, and c) crystalline carbon layer produced by pressing of commercial graph-ite flakes. d) shows the radial electron density distribution of the fast Fourier transforms of the TEM micrographs.

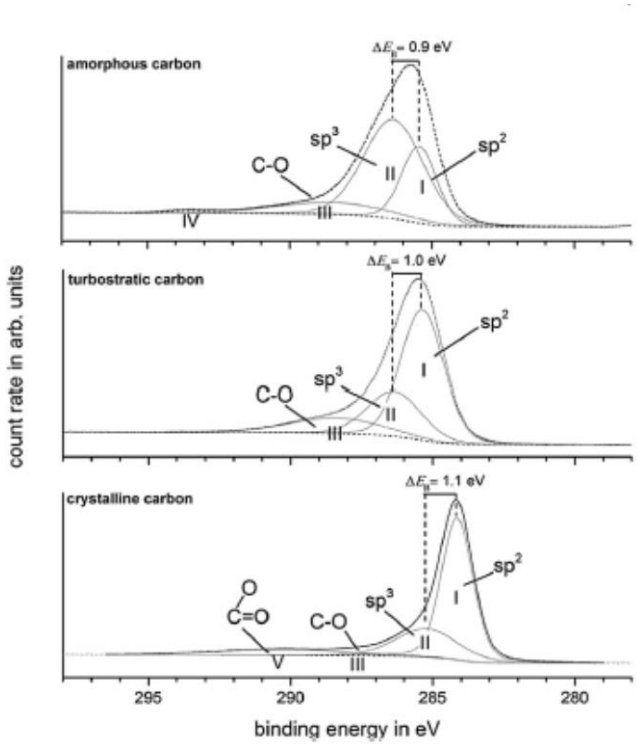

Figure 3: XPS as surface method to characterize the surface composition of the 3 carbon membranes und study.

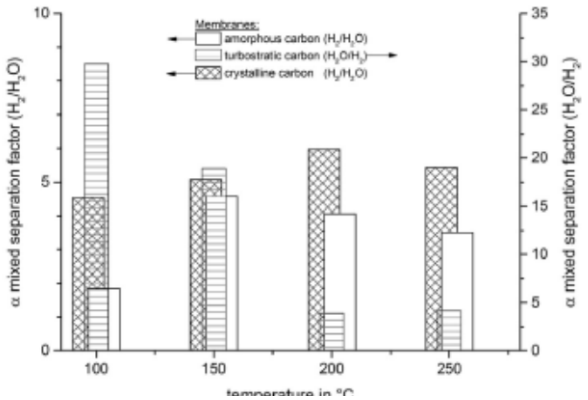

Figure 4: Separation factors of the 3 membranes: Amorphous and crystalline membranes are hydrogen-selective, the turbostratic is hydrophilic.

Reference

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