Project Deliverable 1.1 Executive Summary

Critical review and assessment on the preparation of experimental as well as commercially available bipolar membranes.

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Despite generating great interest over the last two decades for the opportunities bipolar membrane (BPM) processes offer to recycle the acid and base values and reverse neutralization in various industrial processes, bipolar membrane systems have thus far met a limited commercial diffusion. Technical restrictions in the available commercial membranes and high investment cost are generally indicated as the principal reasons for such limited market penetration.

In the framework of the European Project NEW ED, a Collaborative Project (Grant Agreement number 227004) co-funded by the Research DG of the European Commission within the joint RTD activities of the Environment and NMP Thematic Priorities, a literature review has been performed to obtain the state of the art of ion-exchange membranes and to assess reported preparation techniques. The review will be made available through scientific publications. This summary describes the content and extent of the full review.

In the first section of the review preparation techniques of commercial BPMs are assessed with the underlying aim of identifying the state of the market, assessing the limitations of the current technologies, and describing suitable directions for future development of preparation procedures.

The survey reveales that the market of BPM was long dominated by a small group of manufacturers, which included notably Tokuyama Co. and FuMA-Tech GmbH. Nevertheless, in the last few years several new companies in Europe (Solvay Solexis) and China (Tianwei Membrane Technology) suggest that, despite the so far limited diffusion of BPMs, the interest in the further development of the technology remains high.

The main concerns with the currently available BPMs are linked to their long-term durability, stability of operation under highly alkaline conditions, achievement of high product concentrations and purity, and high investment cost. Although the values of potential drop across the membrane reported in the literature (0.9-1.2 V) are quite close to the theoretical minimum for water dissociation (0.83 V in standard conditions), the electrical resistance of the membrane may increase drastically when the rate of water dissociation exceeds the rate of water replenishment in the junction layer.

The investigation of the components of commercial BPMs revealed that various materials are adopted in the preparation of the membranes. Chemically stable polymers such as poly-sulphone are often chosen as the base polymer for the formation of the ion-exchange films but other materials such as perfluorinated polymers, styrene/divinylbenzene and poly-styrene/vinylbenzoyl-chloride have been used as well in commercial applications. Crosslinking the polymer is generally acknowledged to help improving the stability and durability of the membranes. Catalyst groups aimed at increasing the rate of water dissociation in the intermediate layer are employed as a rule in the preparation of the membranes. The range of available catalysts is described in greater detail.

Different procedures that are described in the literature for the formation and attachment of BPM layers are discussed. In industrial production, the preparation of multilayer BPMs has several advantages with respect to other procedures. With respect to laminated membranes, the preparation of multilayer BPMs involves simpler processes and results in membranes with relatively good properties, although the previously highlighted limitations of the currently available commercial BPMs apply. Single-film BPMs obtained functionalizing the opposite sides of an existing precursor membrane have been suggested as a promising direction of development for the preparation of commercial membranes due to their high durability.

In the second section bipolar membrane preparation procedures of non-commercially available membranes reported in the public literature are outlined, with a special focus on the catalytic intermediate layer. In addition membrane materials reported in the literature for tailor-made membranes and the corresponding membrane layers are summarized. The second part further focuses on the intermediate layer and the membrane catalysts implemented. A list of macromolecules, metallic compounds and inorganic materials is presented and analyzed regarding their effectiveness. The second part of the report finishes with a description of innovative production techniques and of measures for reduction of co-ion leakage.

A patent overview focusing on the bonding of ion-exchange layers, on structural modifications of the bipolar membrane or its layers and on patents regarding the application of bipolar membranes rounds-up the review on bipolar membranes.