

# **Artificial Membranes for Life Sciences: Lessons learnt from dialysis applications**

\*Jörg Vienken, University of Applied Sciences (THM), Gießen, Germany  
e-mail: vienken.usingen@gmail.com

**Keywords:** Membrane polymers, biocompatibility, leachables, sterilisation procedures

**Introduction:** Membranes for haemodialysis represent a unique success in medical device application. It spans a time frame from haemodialysis as an experimental therapy to today's routine application. In the early 1980ies, the number of dialysis patients worldwide depended on the availability/production capacity of dialysis membranes and increased accordingly. Today, due to the continuous increasing patient numbers, reaching a figure of 2,5 million in 2016, capillary membranes for dialysis have become a commodity with an annual production of more than 600 million km. This is equivalent to four times the distance between the Earth and the Sun. During the optimisation of membrane production and application, a series of learning curves had to be adopted which might yield some information for the use of membranes in other realms of clinical application.

**Membrane performance:** Recent years have seen a shift in the dialysis market from low- to high flux membranes. They differ in their ultrafiltration coefficient (UFC) or their hydraulic permeability. This can be explained by the still unknown profile of uremic retention solutes to be removed. The target of current concepts is, therefore, the removal of molecule families rather than of individual moieties. High ultrafiltration rates using the principle of solvent drag are, thus applied with hemodiafiltration as a major treatment modality. Blood compatibility of dialysis membranes has been successfully achieved by the selection of appropriate polymers. It is interesting to note, that polymers bearing hydroxyl-groups provoke the activation of the complement system and may stimulate adverse events. The golden polymer standard for haemodialysis has turned out to be poly-sulfone and its derivatives. All membrane manufactures in the world are now using this polymer due to its versatile character.

**Membrane leachables:** Survival of patients suffering from end stage kidney disease and treated by haemodialysis therapy has increased in

recent years. Thus, the long term and repeated exposure of patient blood to foreign surfaces, i.e. membranes, tubing and device housing opens the door for leachables from the polymer bulk to be eluted to blood circulation. Among them are plasticizers and polymer compound, such as bis-phenols. These molecules are also called endogenous hormones, because they may interfere with receptors for sexual hormones and initiate unwanted signals to cells and tissue. Research focus of recent years has been directed towards their removal or avoidance.

**Membrane sterilisation procedures:** Membranes belong to the category of medical devices and have to be sterile and pyrogen free prior to final clinical application. Five sterilisation techniques are currently used for this purpose, i.e., ethylene oxide, steam,  $\gamma$ - and  $\beta$ -irradiation, as well as aldehydes (formalin, glutaraldehyde). Clinical adverse events have been observed when some sterilisation techniques have interfered with individual membrane polymers. Knowledge on these possible adverse events is thus crucial.

**Membranes, as scaffolds for biological cells:** Current *in vitro* and *in vivo* research is directed towards the development of membrane devices to be used as 3D scaffolds for the culture of biological cells. As a consequence, investigations of surface properties, in terms of polymer purity, membrane design and 3D geometry are of paramount importance.

**Summary:** Membranes for the use in haemodialysis have proven their versatility for many different applications. Results and related experience of *in vitro* investigations and of clinical application on such devices may serve as a common background for membrane applications in life sciences.