Electronic Supplementary Information (ESI)

Amyloid Hybrid Membranes for Removal of Clinical and Nuclear Radioactive Wastewater

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Materials and Methods

Preparation of the hybrid membrane

Whey protein isolate was purchased from Hilmar ingredients, USA. Whey protein amyloid fibrils were prepared without any further purification by heat denaturation of the 2 wt% monomer solution at pH 2 for 5 hours. Activated carbon (Norit SAE Super, particle diameter D_{50} 15 µm) was purchased from Cabot. Whey protein hybrid membranes were assembled and kindly provided by BluAct technologies GmbH. The process of making the depth filter sheet hybrid membrane is similar to paper making process. Initially the paper pulp is mixed with the activated carbon and amyloid firbils solution. Water removed from this mixture by the vacuum filtration followed by pressing and drying process. The final membranes are composed of 10% of amyloid fibrils with 40% activated carbon and the remaining 50 % of cellulose acting as a binding matrix. The membranes were used directly for radioactive nuclear waste removal experiments as received. For all the tests 53 mm diameter of the membrane having a thickness of 3mm was used.

Syringe-aided filtration

For the experiments, prepared amyloid-carbon hybrid membranes having the amyloid fibrils concentration of 10 wt% were used. The membrane was cropped into a round shape to fit a filter holder, where it was subsequently installed. The edges of the screwcap of the adaptor were greased with Silicon Lubricant® to ensure a leak-proof and tight fit. Before filtration, the membranes were moistened with water. The radionuclide of interest was diluted in water, before manually injecting it into the filter holder with the use of an attached syringe. The flow rate was adjusted by manually applying pressure onto the syringe.

For all experiments, aqueous stock solutions of the corresponding radionuclides were prepared using an ISOMED 2010 (NuviaTech Healthcare 92500 Rueil-Malmaison, France) dose calibrator. Ga-68 was obtained as GaCl from a clinical Ge-68/Ga-68 generator (ITM AG, 85748 Garching, Germany). Wastewater samples were not diluted before filtration. For the estimation of the initial radioactivity, the wastewater containing Lu-177 and I-131 was assessed by using a wastewater counter ISOMED 2151 (NuviaTech Healthcare). To avoid results biased by radionuclide decay during the experiment, activities of unfiltered controls and filtrates were simultaneously measured only after completion of the filtration experiments. Further, measurements were acquired with a PERKIN ELMER 2470 wizard automatic gamma counter and decay corrected for the acquisition time.

Planar scintigraphy and SPECT imaging

Membranes filtering Tc-99m, Lu-177, I-131 were imaged with planar scintigraphy and single-photon emission computed tomography (SPECT) using a Philips bright view XCT (Philips Health Systems, 22335 Hamburg, Germany) with two detector heads. In planar scintigraphy, membranes were placed in an acrylic petri dish directly onto one camera head, to minimize their distance to the detector; the other had was not used here. SPECT imaging was performed with both camera heads. For Tc-99m

measurements, we used a low-energy collimator, a medium energy collimator for Lu-177 measurements and a high energy collimator for I-131 measurements. The acquisition was run until 1 Mio counts were acquired per image.

PET/CT imaging

Positron emission tomography combined with computed tomography (PET/CT) images of membranes filtering Ga-68 were acquired on a Siemens Biograph 128 mCT (Siemens Healthcare GmbH, 91052 Erlangen, Germany). Membranes were placed in the middle of the field of view, and a single bed-position was acquired during 85 min in list-mode using time of flight (TOF). Images with voxels sized 1.6 mm * 1.6 mm * 1.5 mm were reconstructed using the TrueX algorithm with CT based attenuation correction and model-based scatter correction. For post-reconstruction filtering, we used an isometric Gaussian of 1 mm full width at half maximum.

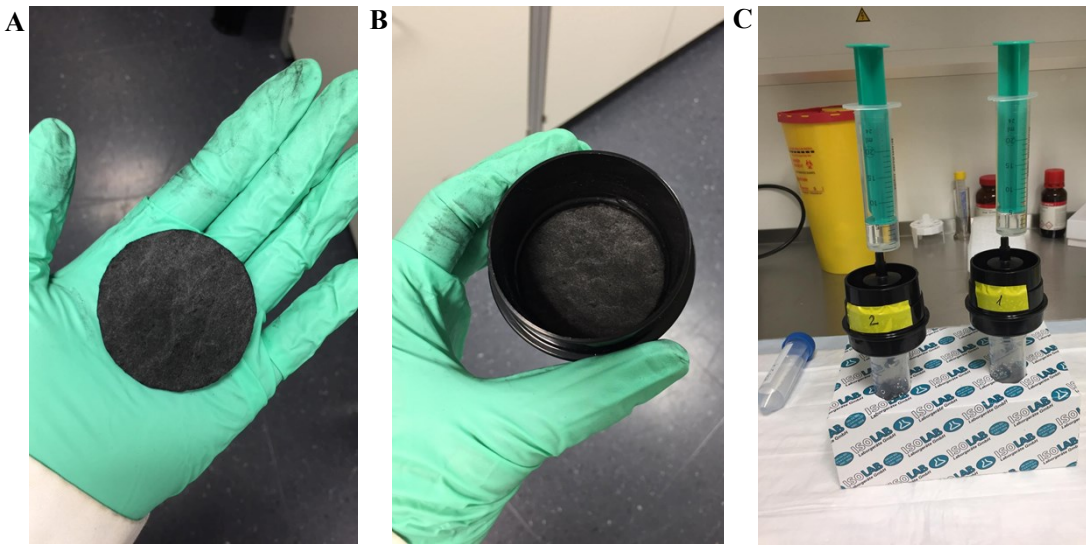

Fig. S1 Syringe aided filtration setup: From left to right: (a) Cropped filter membrane, (b) membrane installed in adaptor®,(c) final experimental filtration setup.

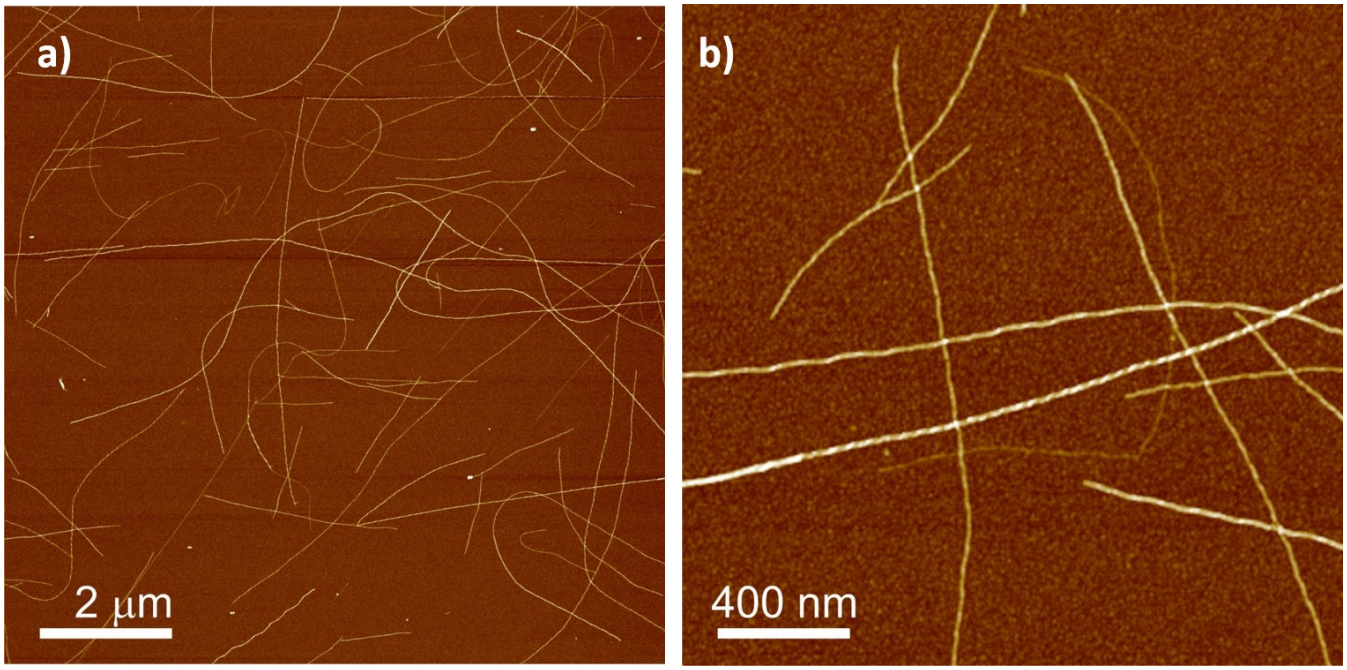

Fig. S2 Atomic force microscopy images of the protein fibrils.

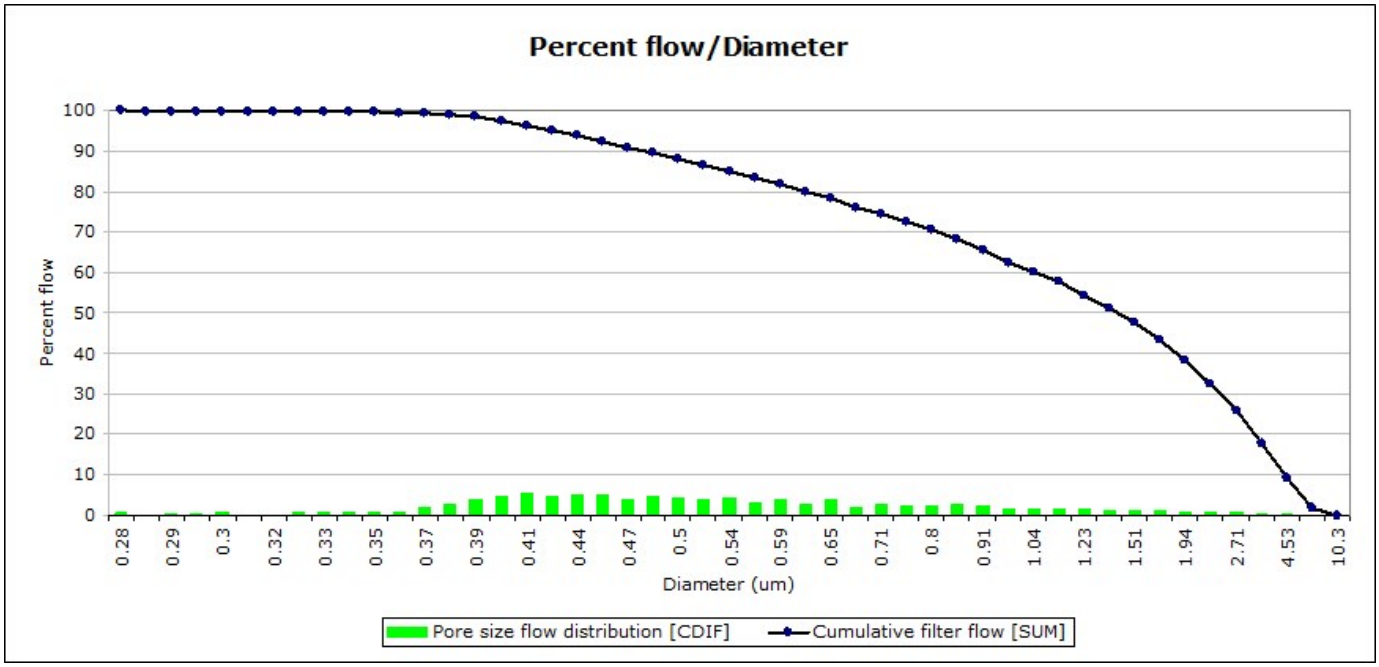

Fig. S3 Pore size distribution of the hybrid membrane

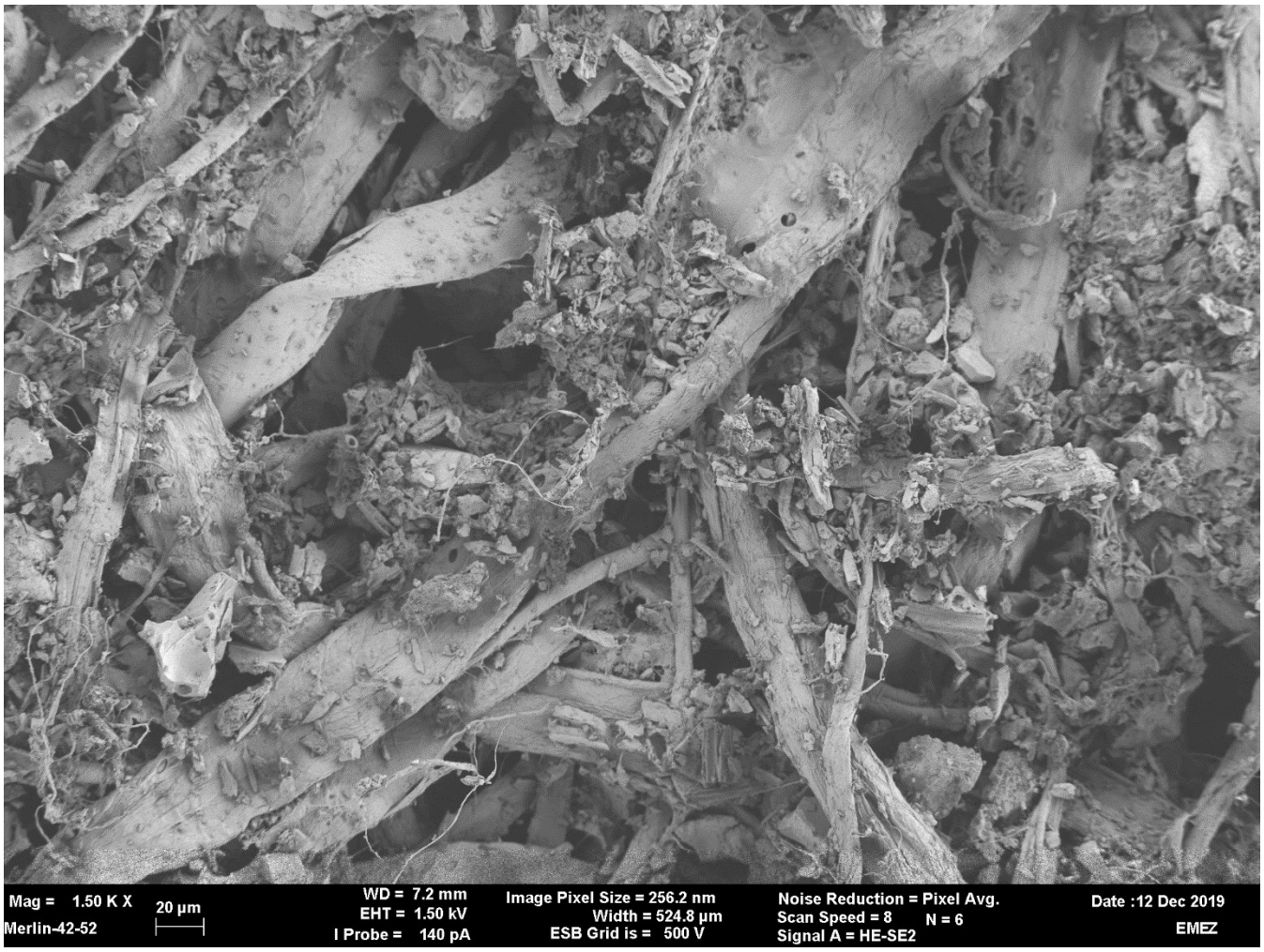

Fig. S4 Scanning electron microscope images of the hybrid membrane