Electronic Supplementary Material (ESI) for RSC Advances.
This journal is © The Royal Society of Chemistry 2021

Supplementary information

Charged ultrafiltration membranes based on TEMPO-oxidized cellulose nanofibrils /poly (vinyl alcohol) antifouling coating

Andrea Aguilar-Sanchez[1], Blanca Jalvo[1], Andreas Mautner[2], Ville Rissanen[3], Katri S. Kontturi[3], Hani Nasser Abdelhamid[1], Tekla Tammelin[3] and Aji P. Mathew[1 *]

[1]*Division of Materials and Environmental Chemistry, Stockholm University, Frescativägen 8, 10691, Stockholm, Sweden*

[2]*Polymer and Composite Engineering (PaCE) Group, Institute of Materials Chemistry and Research, Faculty of Chemistry, University of Vienna, Währinger Str. 42, 1090 Wien, Austria*

[3]*VTT Technical Research Centre of Finland, Solutions for Natural Resources and Environment, P.O.Box 1000, FI-02044 VTT, Finland*

Figure S1. AFM 2D topography of T-CNF.

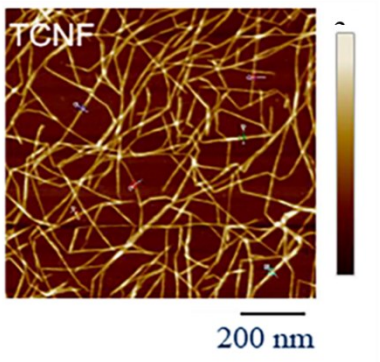


Figure S2. a) Experimental set-up for a) MWCO and b) permeance measurements *(P- Permeate, P1- Feed pressure, F-Feed)*

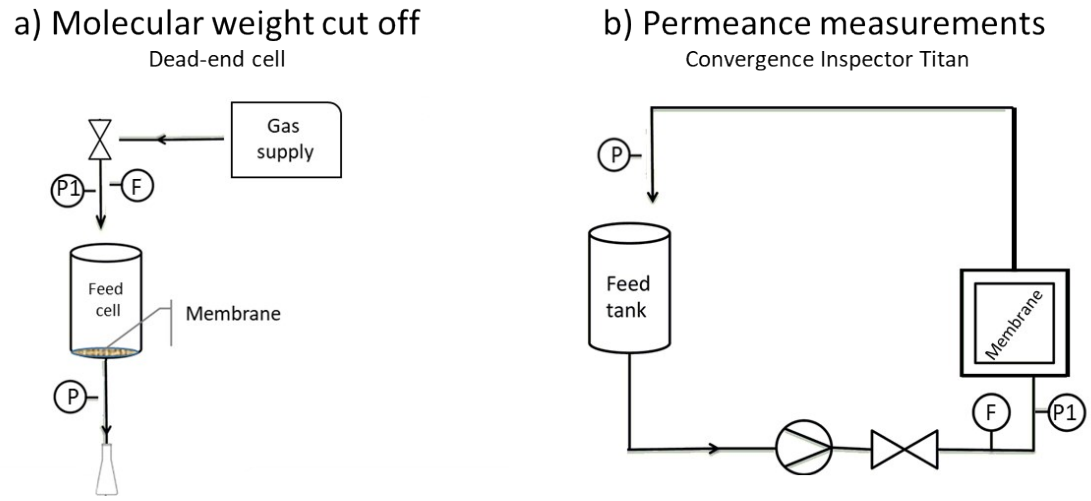


Figure S3. a) SEM image of the coated surface after 24 h of continuous flux, b) SEM image of a tilted coated sample, c) Scheme of the membrane's cross-section.

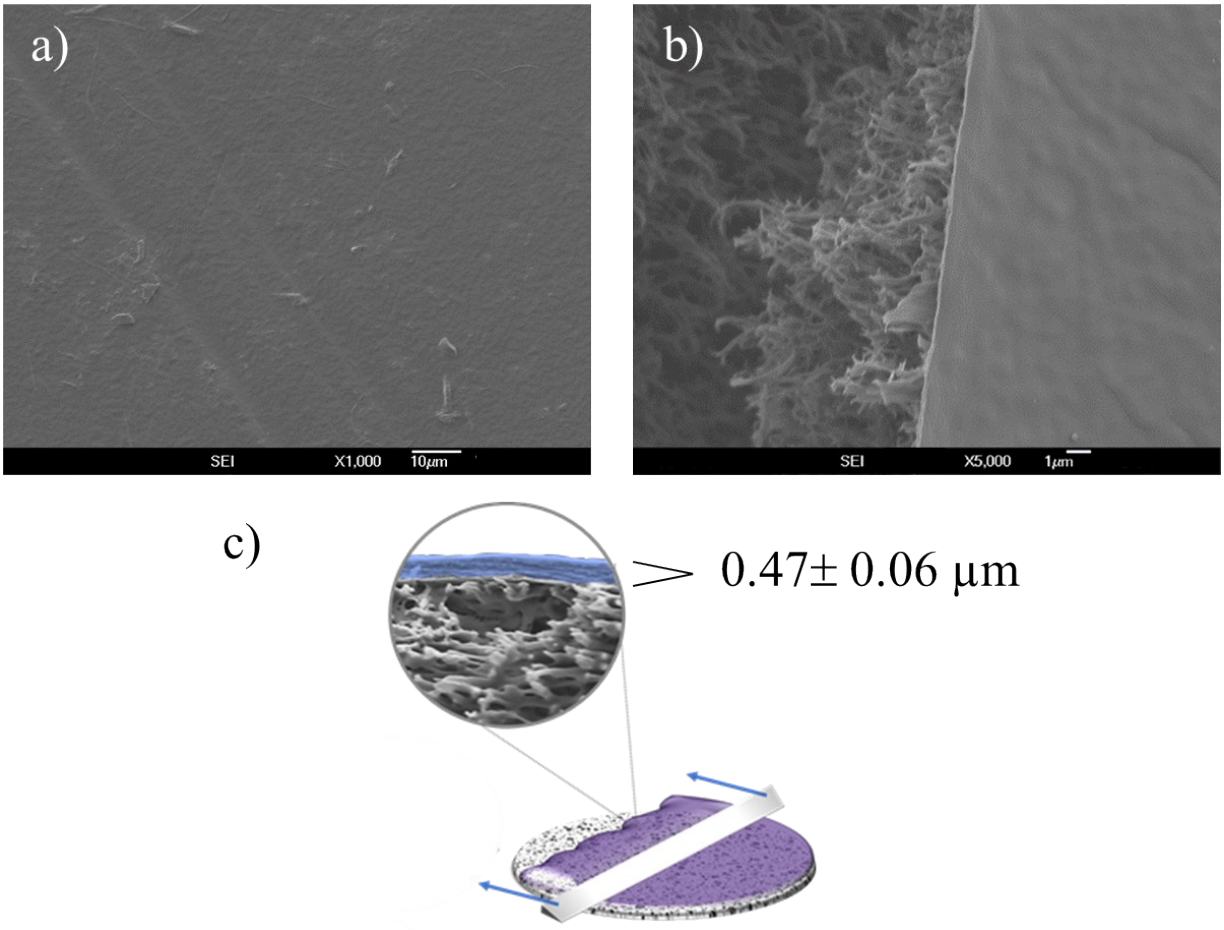


Figure S4. a) N_2 adsorption-desorption isotherm and b) pore size distribution determined using DFT model of T-CNF/PVA coated membrane.

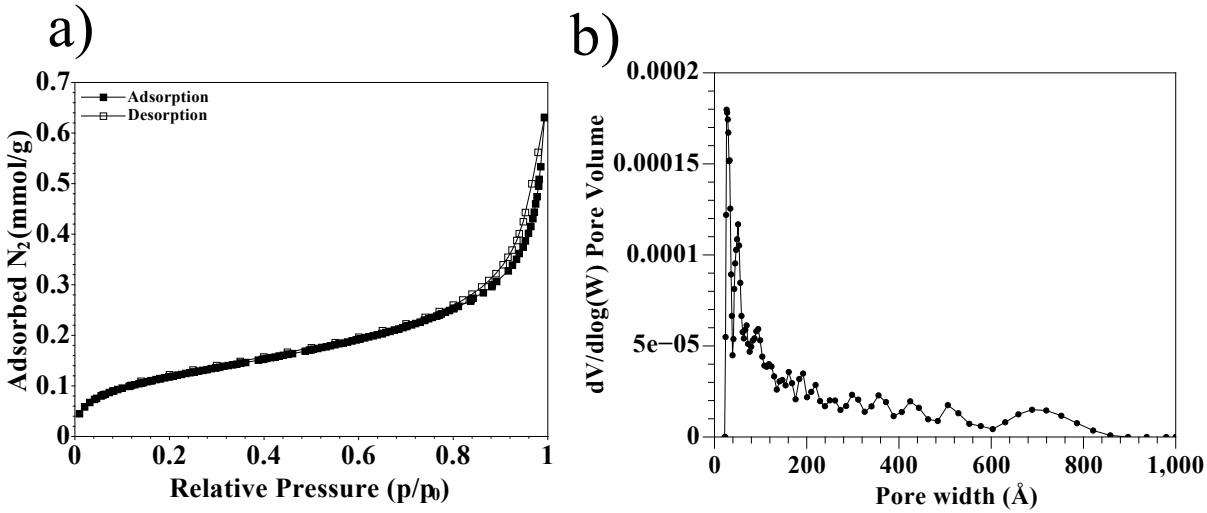
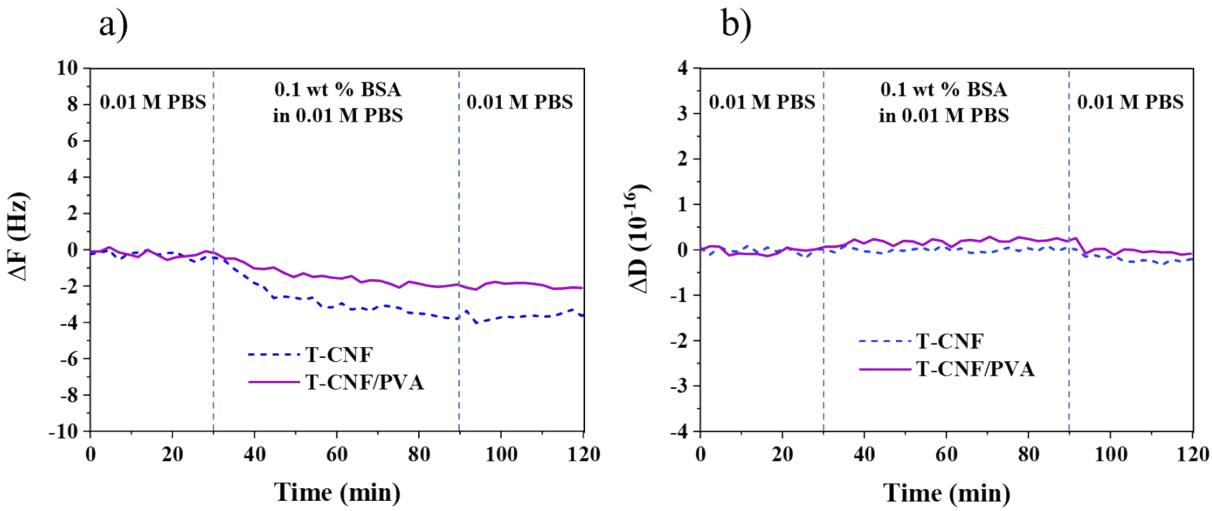


Figure S5. Change in a) frequency (ΔF), and b) dissipation (ΔD) of T-CNF and TCNF/PVA thin films as a function of time due to adsorption of BSA at solid-liquid interface, detected with QCM-D (f_0 = 5 MHz, n = 5, f_5 = 25 MHz).



Quartz Crystal Microbalance with Dissipation Monitoring (QCM-D)

In QCM-D the oscillation of a piezoelectric quartz crystal sensor under a pulsating electric field is dependent on the total oscillating mass [1]. If a layer covering the sensor can be considered even in its distribution, rigid, elastic and small in mass compared to the sensor crystal, according to the Sauerbrey equation (eq. 1) [2] a change in frequency is directly proportional to a change in areal mass:

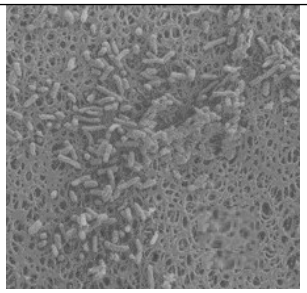
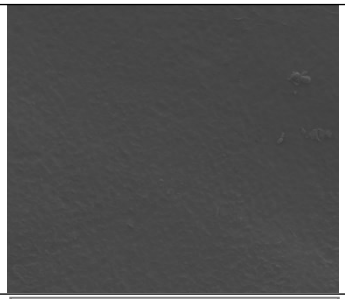
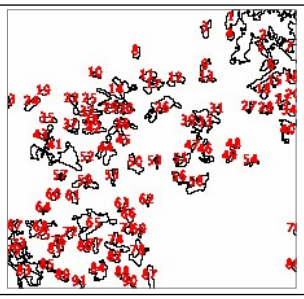
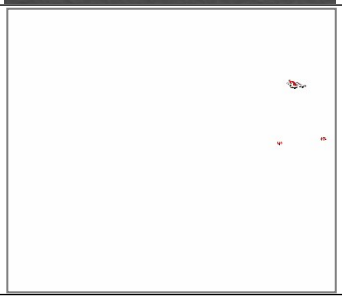
$$\Delta m = -C\frac{\Delta f}{n} \qquad (1)$$

where Δm is the mass change per unit surface, $\Delta f = f - f_0$ is the change in resonance frequency (f_0 being the fundamental resonance frequency), C is the sensitivity constant of the sensor and n is the measurement overtone number (n=1, 3, 5, 7, 9, 11). At the same time, as the voltage is periodically cut off, frictional losses in the covering layer cause the oscillation to decrease gradually and the resonance amplitude to dampen. This energy dissipation, D, represents the viscoelastic properties of the layer, which can be presented as (eq. 2):

$$D = \frac{E_{disspation}}{2\pi E_{storage}} \quad (2)$$

where $E_{dissipation}$ is the dissipated energy and $E_{storage}$ the total energy stored during a single oscillation cycle. A change in dissipation, ΔD, gives a qualitative measure of the rigidity and softness of the layer covering the sensor surface. The layer is considered fully elastic and rigid when $\Delta D \leq 1 \times 10^{-6}$, and the overtones of Δf and ΔD do not spread in a significant manner.

Figure S6. Quantification of bacteria using Image J.

Samples	PES substrate	PES substrate + T-CNF/PVA membrane
SEM		
Image J visualization		
Bacterial coverage area * (%)	10.2	0.04

**Analysis performed on 3 SEM images per sample.*

References

1. F. Höök, M. Rodahl, P. Brzezinski and B. Kasemo, Langmuir, 1998, 14, 729–734.
2. G. Sauerbrey, Zeitschrift für Phys., 1959, 155, 206–222.