Supplementary information

Movie S1: Manipulation of a 16 cm^2 self-supporting 35 nm thick Hybrid_1 nanofilm floating in ethanol.

Movie S2: Aspiration and release of a 16 cm^2 Hybrid_1 nanofilm through a micropipette with a tip diameter of 320 μm.

Movie S3: Permeation of ethanol through a freely suspended Hybrid_1 nanofilm (35 nm thick) attached at the bottom of a glass tube.

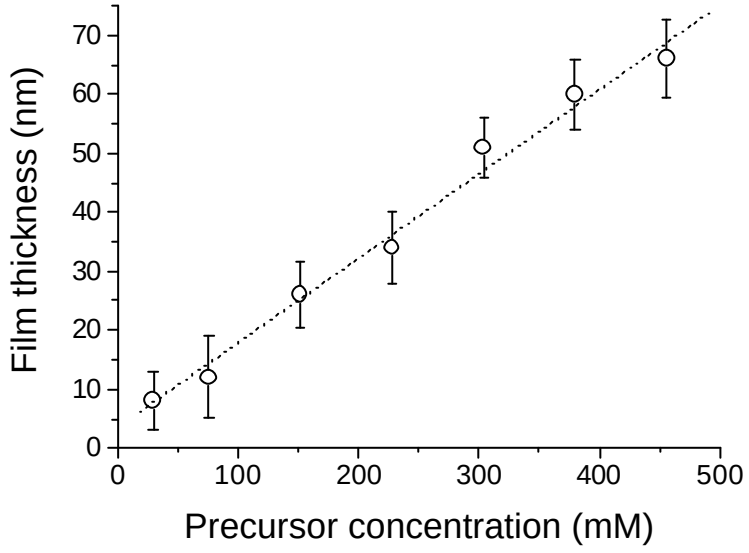

Figure S1. Thickness of the free-standing Hybrid_1 nanofilms as a function of the precursor concentration in chloroform.

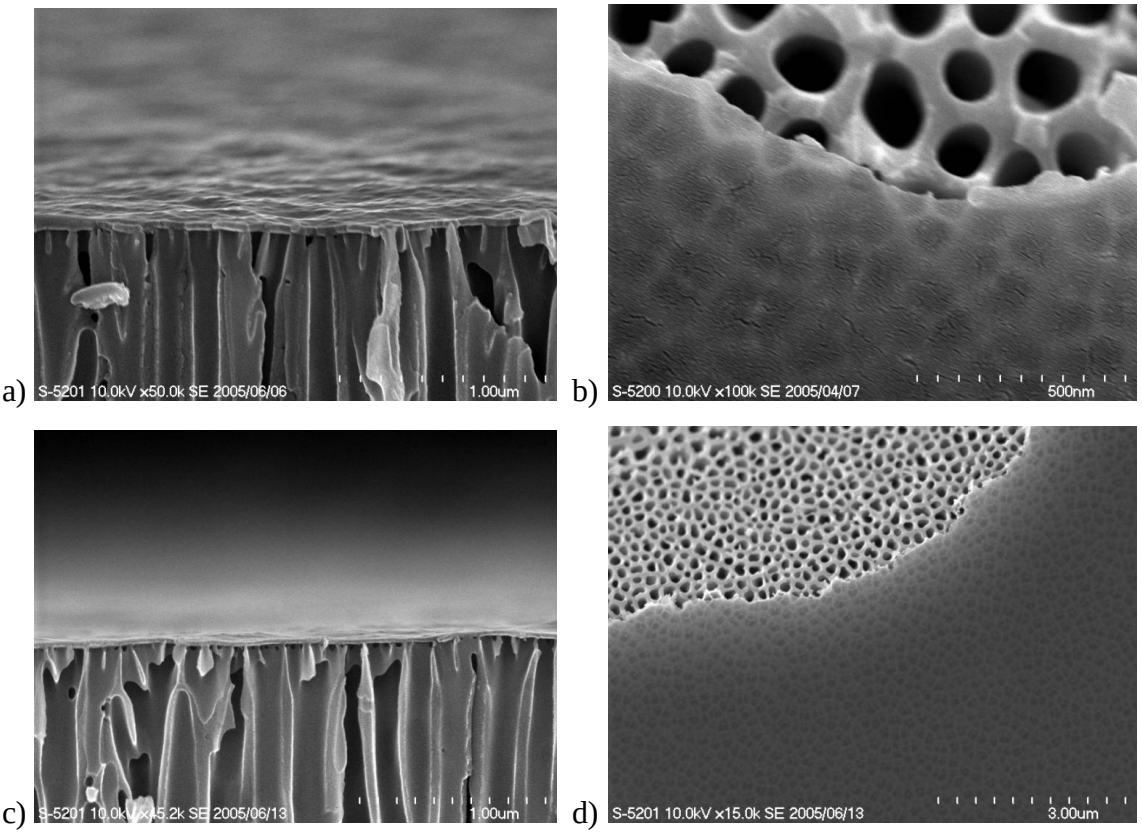

Figure S2. Additional SEM pictures of Hybrid_2 and Hybrid_3 nanofilms. a, SEM side-view image of a Hybrid_2 nanofilm (42 nm thick) on an ANODISC. **b**, SEM top-view image a Hybrid_2 nanofilm. **c**, SEM side-view image of a Hybrid_3 nanofilm (29 nm thick) on porous alumina. **d**, SEM top-view image the Hybrid_3 nanofilm.

The bulging test was conducted in accordance with the known routine (see references 2, 15 and 41). The tensile stress σ and tensile strain ε of ultrathin films can be measured by applying an overpressure to one side of a freely suspended film that covers a metal plate with a circular hole and measuring the resulting deflection of the film. In the present study, the applied pressure was controlled with a digital manometer and the membrane deflection was monitored with an optical microscope. A scheme of the set-up is presented in figure S3.

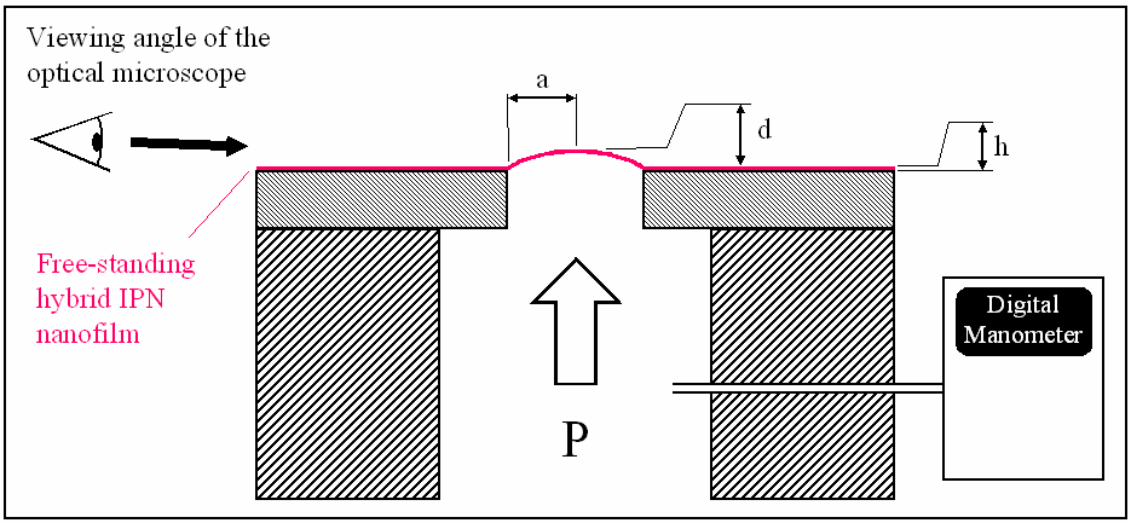

Figure S3. Scheme of the bulging experiment. The pressure, P, vertical displacement of the film centre, d, radius of the opening, a, and film thickness, h, are indicated in the figure.

From such an experiment, it is possible to determine the ultimate tensile stress σ and the ultimate tensile strain ε (respectively defined as the strength and elongation at membrane rupture) using the following formulas (explained in Ref. 15):

$$\sigma = (P \times a^2) / (4 \times h \times d)$$

$$\varepsilon = (2 \times d^2) / (3 \times a^2)$$

Where P is the pressure required to break the membrane, a is the radius of the opening (0,5 mm in our set-up), h is the membrane thickness, and d is the deflection of the membrane centre at rupture. Using this method, the average ultimate mechanical strength σ of the Hybrid_1 specimen was determined as 105 Mpa (average value from 15 samples). The lowest value is 93 MPa and the highest 136 MPa. The average ultimate elongation ε is 2,6 %. These results qualitatively agree with those reported in the literature for organic/inorganic hybrid nanofilm (Ref 2 and 15) and clearly demonstrate the robustness of the hybrid IPN nanomembranes.

A detailed analysis of the ultimate mechanical properties of hybrid nanofilms as a function of the composition (organic/inorganic molar ratio) and the organic network crosslinking density is currently under investigation and will be reported elsewhere.