Oil removal from water-oil emulsions using magnetic nanocomposite fibrous mats

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Supplementary information

S. 1. Determination of optimal Span80 amount.

Different amounts of Span80, from 0.5 to 1.5 v%, were employed to obtain stable water-oil emulsions following the procedure described in the experimental section. It was found that lower amounts of Span80 do not lead to the formation of stable emulsions. Moreover, in Figure S.1 it is shown how the absorption capacity of the fibers decreases when the concentration of Span80 increases in the emulsion. Therefore, it was established that 0.5 v% was the optimal amount of Span80 to perform the study.

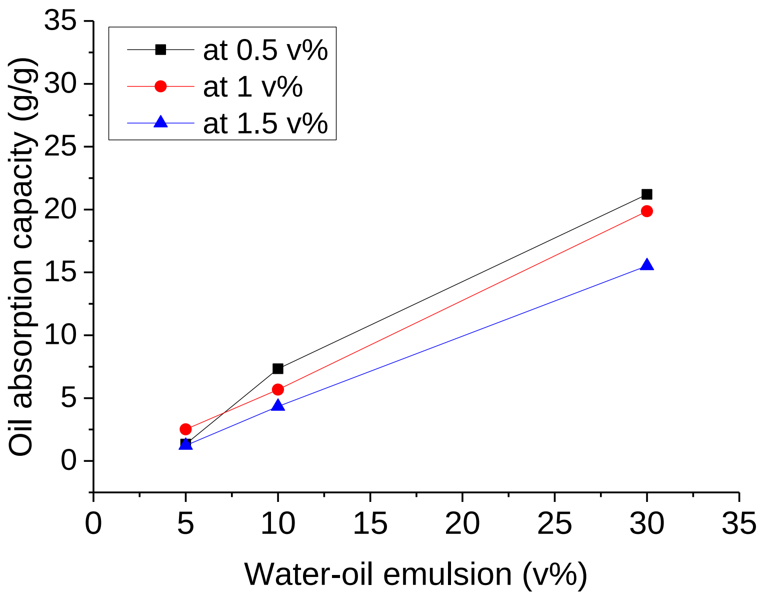

Figure S.1: Oil absorption capacity of MFbs after dipping in stable emulsions with oil concentrations from 5 to 30 v% and different Span80 concentrations (0.5, 1, and 1.5 v% in oil).

S. 2. Evolution of the absorbed mass: determination of the absorbed oil and water.

The weight of the samples was measured periodically up to 11 days after the performance of the experiments to ensure the complete water evaporation from the samples, finding that their weight was stabilized after 7 days (Figure S.2.a). Figure S.2.b shows the water and oil absorption capacity of MFbs after 15 min dipped in the different emulsions, and measured after their weight stabilization (after 7 days, the oil absorption capacity was determined from the remaining mass, whereas the water absorption capacity was determined from the evaporated mass). It is found that at low oil concentrations the MFbs present similar values for the water and the oil, but at high oil concentrations the water absorption is clearly below the oil absorption.

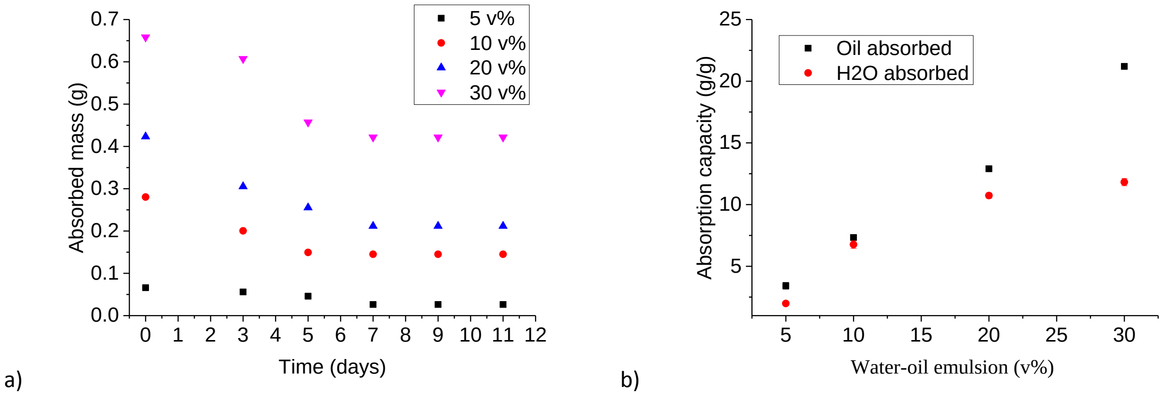

Figure S.2. (a) Evolution of the total mass absorbed (water + oil) by the MFbs after extraction from the emulsions. (b) Water and oil absorption capacity of the MFbs after dipping for 15 minutes in the different emulsions, measured after their weight stabilization (7 days).

S. 3. Mechanical properties of non-pressed and pressed PFbs.

The Young's modulus of the fibrous mats was measured from the slope of stress–strain curves created during tensile tests performed using an Instron 3365 machine. The extension rate was 1 mm min^{-1}, with a gauge length of 10 mm. For each material, five specimens were tested from which the mean and standard deviation were calculated. The results are shown in Figure S.3.

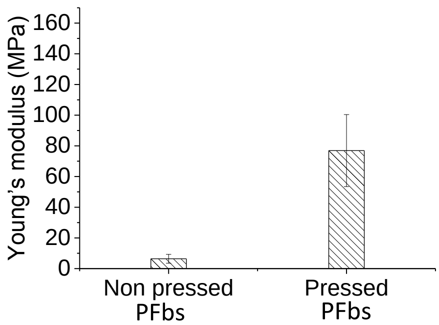

Figure S.3. Mean values of Young's modulus of non-pressed and pressed PFbs.

As expected, the pressed fiber mats present better mechanical performance in terms of Young's modulus compared to the non-pressed ones, showing an enhancement of about 1100%, which can be attributed to the improvement of the entanglement among individual fibers. On the contrary, the non-pressed fiber mats present poor entanglement among fibers, resulting in a low Young's modulus and a significant dispersion of the fibers in the liquids during the attempts to test their oil absorption performance.

S. 4. Kinetics of the absorption of oil droplets by the fibers.

Figure S.4 shows the absorption of a 5 µl oil drop in both kinds of samples. The MFbs present a faster absorption (higher oil absorption rate) and therefore a higher oleophilicity than the PFbs.

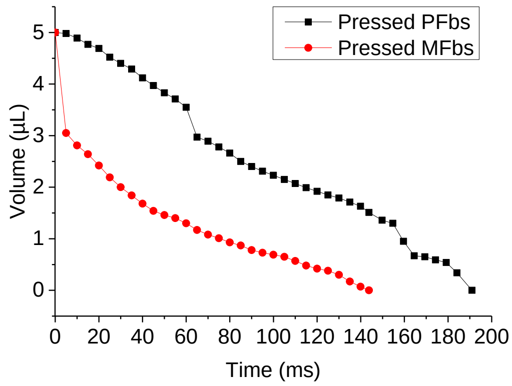

Figure S.4. Evolution of the volume of a 5 µl oil drop absorbed by the MFbs and PFbs.

S. 5. Stability of the emulsion.

All the emulsions stabilized using Span80 present no changes or phase separation after 60 minutes (Figure S.4).

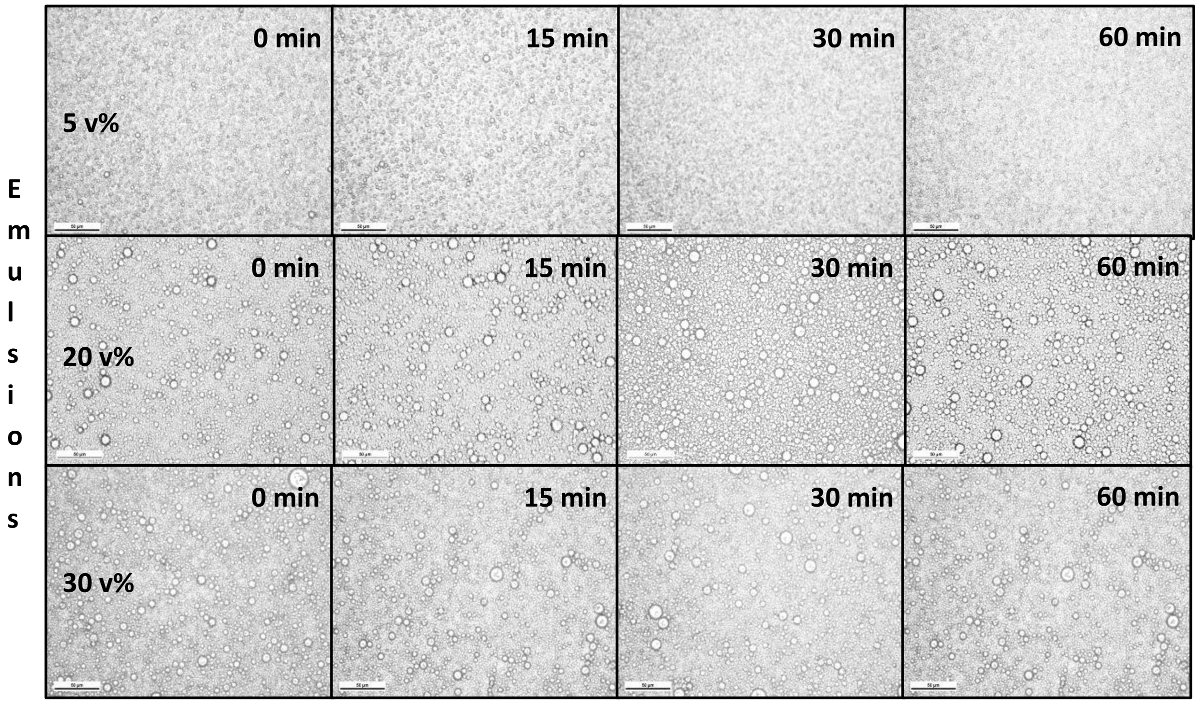

Figure S.5. Sequence of optical micrographs for 5, 20 and, 30 v% oil concentrations at times from 0 to 60 minutes after the emulsion preparation (scale bar corresponds to 50 µm for all the micrographs).

S. 6. Influence of the emulsion:fibers mass ratio on the oil removal capacity.

Different amounts of emulsion, from 1 to 4 ml, were employed to determine the simultaneous maximum oil absorption capacity and removal efficiency in stable water-oil emulsions following the procedure described in the experimental section.

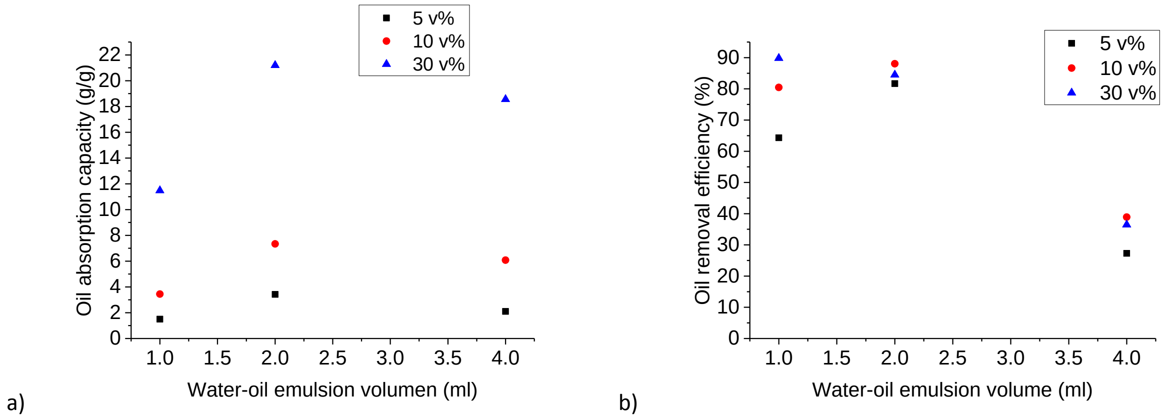

Figure S.6. Oil absorption capacity (a) and oil removal efficiency (b) of pressed MFbs in different amounts of water-oil emulsions with oil contents from 5 to 30 v%.

Then, it is found that mass ratios lower than 100:1 emulsion:fibers (i.e. 2 ml of emulsion and 0.02 g of fibers) do not further improve the oil removal efficiency and do not allow to reach the maximum oil absorption capacity since the amount of oil is not enough, whereas ratios higher than this decrease the oil removal efficiency and do not increase the maximum oil absorption capacity.