Supplementary Information

Comparison between photothermal heating of the membrane and tradiation heating of the feed:

Calculations of laser energy input per extra volume filtrated during laser irradiation:

The laser was set at a power of 1W. This energy was delivered to the membrane during a certain time. The time of the laser irradiation period was calculated for each filtration and the laser energy input (E, Wh) was calculated as the laser power (1 W) multiplied by the average irradiation time (Δt). For each solvent and each filtration, the extra volume that filtrated by use of laser irradiation (ΔV) was calculated as the total volume that filtrated during the laser irradiation period (V_L) minus the volume that would have filtrated during this period without laser irradiation (V_E).

$$V_L = m_L \cdot \rho^{-1} \tag{4}$$

Where m_L is the filtrated mass of solvent during laser filtration (g) and ρ is the solvent density (g L^{-1}).

$$V_E = P_E \cdot A \cdot \Delta P \cdot \Delta t \tag{5}$$

Where P_E is the equilibrium permeance without laser irradiation (L m^{-2} bar^{-1} h^{-1}), A is the active membrane surface (m^2), ΔP is the applied pressure (bar) and Δt is the laser irradiation time (h).

$$\Delta V = V_L - V_E \tag{6}$$

The energy input per extra filtrated volume was then calculated as the product of E and ΔV^{-1} (Wh L^{-1}). It should be stated that these calculations only account for the direct energy input into the membrane system. The electricity needed to operate a laser was not included.

Calculation of the energy needed to heat ethanol and maintain the temperature at 37°C:

The heat capacity of a solvent is the energy needed to heat 1 g of solvent by 1 °C. On average, the filtration cell used in this research contained 50ml of ethanol. The energy needed to heat 50ml of ethanol from 20°C to 37°C was calculated as follows:

$$E = C_p \cdot V \cdot \rho \cdot \Delta T \quad (7)$$

Where C_p is the solvent heat capacity (kJ kg^{-1} K^{-1}), V is the feed volume (L), ρ is the solvent density (g L^{-1}) and ΔT is the temperature difference (17°C). Thus for a 50ml ethanol feed:

E = 1638.5 J = 0.455 Wh

The energy needed to maintain the temperature of ethanol at this level, was dependant on the heat losses to the environment. As an example, the heat loss through the glass wall of the filtration cell can be calculated. The heat transfer coefficient of a "pipe wall" can be calculated as:

$$H = 2 \cdot k \cdot (d_i \cdot ln(d_o \cdot d_i^{-1}))^{-1} \quad (8)$$

Where k is the thermal conductivity of the wall material (glass, 1.05$Wm^{-1}K^{-1}$), d_i is the inner diameter (0.0425m) and d_o is the outer diameter of the glass cylinder (0.048m), so that

H_{glass} = 406 $Wm^{-2}K^{-1}$

The heat loss through the glass cylinder wall can then be calculated as:

$$\Delta Q = H_{glass} \cdot A_{glass} \cdot \Delta T \quad (9)$$

Where A_{glass} is the surface of the cylinder in contact with the feed ethanol and ΔT is the temperature difference with the environment (37°C-20°C=17°C), giving

ΔQ = 0.194 W

And during 11 minutes of filtration (= same as the irradiation time for the laser irradiated filtration),

$\Delta E = 0.035$ Wh

The total energy input that was necessary to heat the ethanol feed to 37° and maintain the temperature for a time equivalent to the laser irradiation period in the laser irradiated filtrations was:

$E = 0.455 + 0.035 = 0.490$ Wh

It should be stated that these calculations only account for the direct energy input into the feed volume. The electricity needed to operate a heating devide such as a thermocouple and its heat loss to the environment were not included.

Comments on the electrical energy use of a laser device compared to a heating device

The laser device will need a high amount of electrical energy to generate the laser beam. In comparison with a heating device (heating plate, thermocouple,…), converting electrical energy to heat, the efficiency will definitely be higher for the latter. If these data are taken into account, it is possible that the difference between the strategies becomes smaller. However, there are other important issues than the energy use that should be taken into account.

- In upscaled set-ups, where large amounts of feed are filtrated, the total energy needed to traditionally heat the feed will become very high.
- In some cases, heating the entire feed is simply not feasible, such as in large-scale waste water purification processes, or it may even be unwanted, when product properties would be negatively affected by increasing temperatures.
- The photothermal heating is not exclusively done by laser light. The possibilities of using normal lamps, optical fibres and LED lights could also be explored, which would significantly decrease the energy use.

The current calculations provide a comparison that is not influenced by the device used to generate the light energy for the photothermal strategy, nor the device generating the heat energy for the traditional strategy.

Li equation to obtain thermal conductivity of two-component liquid mixture [see ref. 38]

$$k_{C,M} = \varphi_1^2 k_{C,1} + 2\varphi_1\varphi_2 k_{C,12} + \varphi_2^2 k_{C,2} \quad (10)$$

and

$$k_{12} = 2 \cdot (k_{C,1}^{-1} - k_{C,2}^{-1})^{-1} \quad (11)$$

Where $k_{C,M}$ is the thermal conductivity of mixture, $k_{C,i}$ is the thermal conductivity of component i and φ_i is the volume fraction of component i.