**Systematic Investigation of MAX Phase (Ti3AlC2) Modified Polyethersulfone Membrane Performance for Forward Osmosis Applications in Desalination**

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Table S1. The composition of control PES substrate and the addition of MAX phase to the membranes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| MAX.  (wt%) | DMAc  (wt%) | PES  (wt%) | PES  (wt.%) | Substrate |
| ----- | 42 | 8 | 16 | M1 |
| ----- | 41.5 | 8.5 | 17 | M2 |
| -----  0.025  0.05  0.075  0.1 | 41  42  42  42  42 | 9  8  8  8  8 | 18  16  16  16  16 | M3  M7  M8  M9  M10 |

Table S2. The composition of control PES substrate and the addition of TFC to the membranes.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Aqueous/organic solution composition | | | | formulation of polymer solutions | | | | Substrate |
| Time (sec) | TMC (wt%) | Time (min) | MPD (wt%) | MAX. (wt%) | DMAc (wt%) | PES (wt%) | PES (wt.%) |
|  | 30 | 0.15 | 2 | 2 | ----- | 42 | 8 | 16 | M4 |
|  | 30 | 0.15 | 2 | 2 | ----- | 41.5 | 8.5 | 17 | M5 |
|  | 30 | 0.15 | 2 | 2 | ----- | 41 | 9 | 18 | M6 |

Table S3. The composition of MAX phase membranes fabrication that addition to the TFC membrane.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Aqueous/organic solution composition | | | | formulation of polymer solutions | | | | TFC membrane |
| Time (sec) | TMC (wt%) | Time (min) | MPD (wt%) | MAX. (wt%)  ***(added to neat 16% PES)*** | DMAc (wt%) | PES (wt%) | PES (wt.%) |
|  | 30 | 0.15 | 2 | 2 | 0.025 | 42 | 8 | 16 | M11 |
|  | 30 | 0.15 | 2 | 2 | 0.05 | 42 | 8 | 16 | M12 |
|  | 30 | 0.15 | 2 | 2 | 0.075 | 42 | 8 | 16 | M13 |
|  | 30 | 0.15 | 2 | 2 | 0.1 | 42 | 8 | 16 | M14 |

Table S4. The composition of MAX phase membranes fabrication that addition to the MPD aqueous solution.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Aqueous/organic solution composition | | | | formulation of polymer solutions | | | | TFC membrane |
| Time (sec) | TMC (wt%) | Time (min) | MPD (wt%) | MAX. (wt%)  ***(added to MPD solution)*** | DMAc (wt%) | PES (wt%) | PES (wt.%) |
|  | 30 | 0.15 | 2 | 2 | 0.025 | 42 | 8 | 16 | M15 |
|  | 30 | 0.15 | 2 | 2 | 0.05 | 42 | 8 | 16 | M16 |
|  | 30 | 0.15 | 2 | 2 | 0.075 | 42 | 8 | 16 | M17 |
|  | 30 | 0.15 | 2 | 2 | 0.1 | 42 | 8 | 16 | M18 |

Table S5. The composition of MAX phase membranes fabrication that addition to the TMC organic solution.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Aqueous/organic solution composition | | | | formulation of polymer solutions | | | | TFC membrane |
| Time (sec) | TMC (wt%) | Time (min) | MPD (wt%) | MAX. (wt%) ***(added to TMC solution)*** | DMAc (wt%) | PES (wt%) | PES (wt.%) |
| - | 30 | 0.15 | 2 | 2 | 0.025 | 42 | 8 | 16 | M19 |
|  | 30 | 0.15 | 2 | 2 | 0.05 | 42 | 8 | 16 | M20 |
|  | 30 | 0.15 | 2 | 2 | 0.075 | 42 | 8 | 16 | M21 |
|  | 30 | 0.15 | 2 | 2 | 0.1 | 42 | 8 | 16 | M22 |



(a)



(b)

Figure S1. Fourier-transform Infrared (FTIR) analysis for all the polyethersulfone (PES) support layer membranes before and after the interfacial polymerization (IP) reaction and before and after adding the MAX phase. (a) M1 PES 16%, M2 PES 17% and M3 PES 18%. (b) M5 TFC, M7 and M9 MAX addition with PES 16%. (c) M11 and M13 TFC, and M15 TFC with MAX addition. (d) M17, M19 and M21 TFC with MAX addition. (e ) M1, M7, and M13.

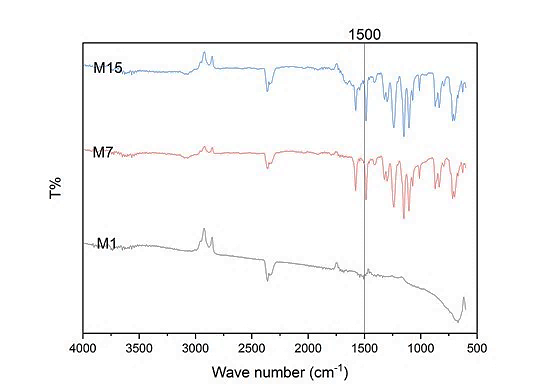


(c)



(d)

Figure S1 Continued



**627**

**1611.83 1500**

**(e)**

Figure S1 Continued

|  |  |
| --- | --- |
|  |  |
|  |  |
|  |  |

Figure S2: Static pure water contact angle of pristine PES and PES membrane with TFC active layer, as well as with varying wt.% of MAX phase.

|  |  |
| --- | --- |
|  |  |
| **(a)** | **(b)** |
|  | |
| **(c )** | |

Figure S3: (a) M4, Cross section. (b) M11, Cross section. (c) M13, Cross section.

|  |  |
| --- | --- |
|  |  |
| **(a)** | **(b)** |
|  |  |
| **(c)** | **(d)** |
|  | |
| **(e)** | |

Figure S4: (a) M1, Surface section. (b) M2, Surface section. (c) M3, Surface section. (d) M7, Surface section. (e) M9, Surface section.