Efficient pervaporation for ethanol dehydration: Ultrasonic spraying preparation of polyvinyl alcohol (PVA)/ Ti$_3$C$_2$T$_x$ nanosheet mixed matrix membranes

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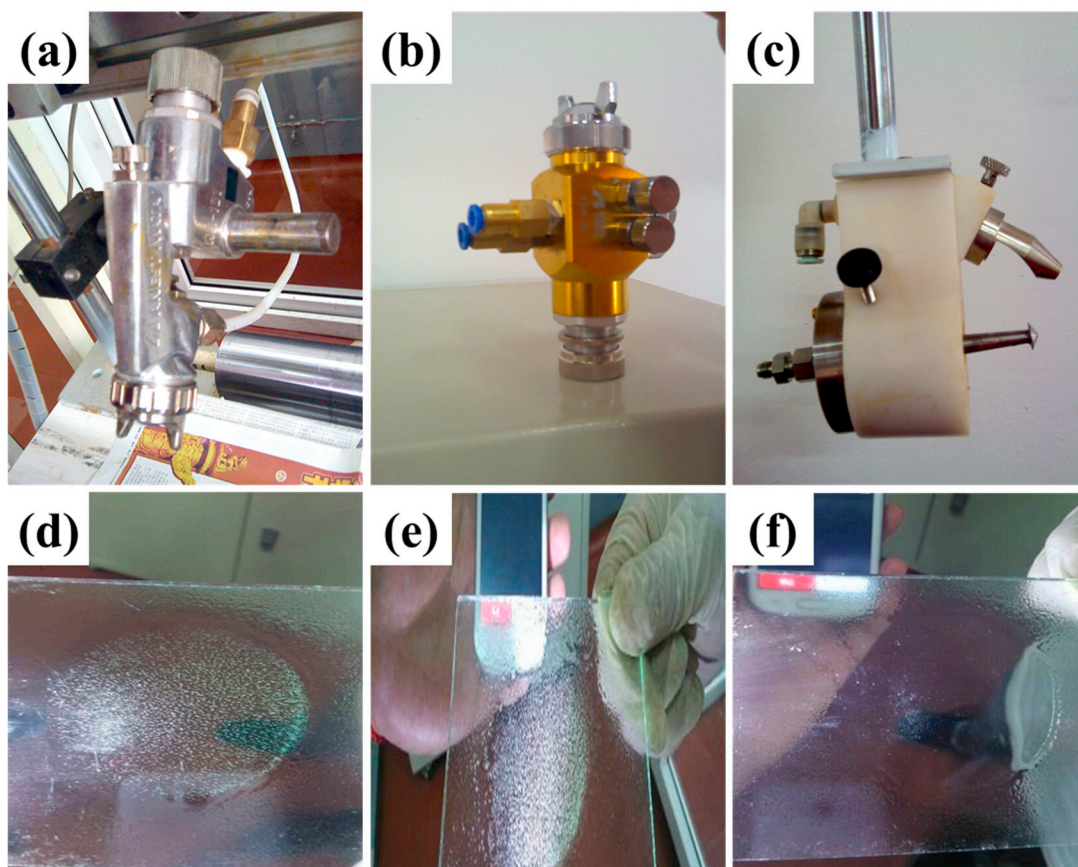Figure S1. Photograph of the homemade PV device

Figure S2. Two different types of gas dynamic spray nozzles, (a) WA-101 and (b) TOF-30-1.5 (Anest-Iwata. Co. Japan), were tried in our spraying processes. (c) ultrasonic spraying nozzle (FSW-6001-L, Funsonic Co. Ltd. China) used in the preparation of the membranes. (d), (e) and (f) were the sprayed fine droplets of the PVA-based solutions on the glass plates after the solutions were puffed out from the WA-101, TOF-30-1.5 and FSW-6001-L, respectively.
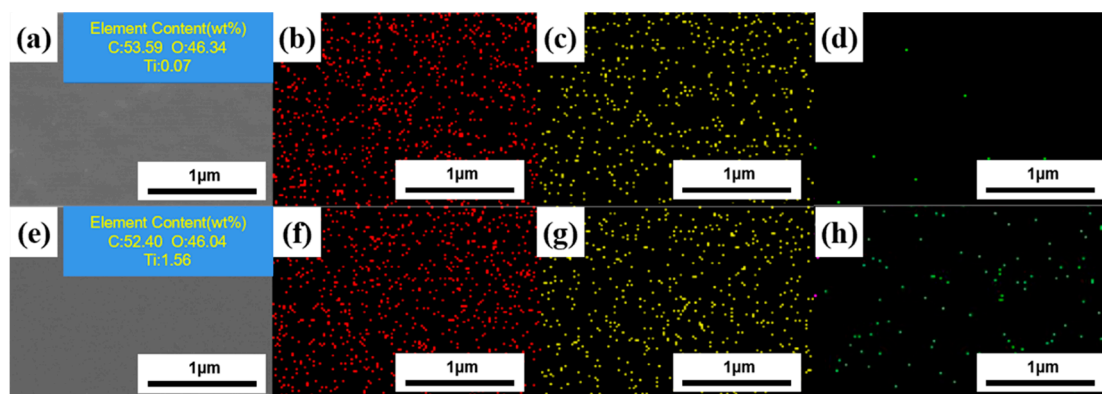
Figure S3. (a) and (e) SEM images, EDX mapping images of (b) and (f) C element, (c) and (g) O element, (d) and (h) Ti element in the PVA and PGM-0 membranes' top-surface, respectively.

Table S1. The PV data for all the prepared composite membranes in this work

Samples	Water flux (kg·m^{-2}· h^{-1})	Separation factor
PVA	0.26±0.03	125.4±36.9
PG	0.18±0.04	133.6±28.4
PGM-0	1.21±0.02	1126.8±33.7
PGM-1	1.05±0.03	1108.4±31.2
PGM-2	0.95±0.02	874.3±29.6
PGM-3	0.92±0.03	732.8±30.7
PGM-4	0.88±0.04	687.5±28.4
PGM-5	1.08±0.03	1084.9±35.4
PGM-6	0.96±0.04	823.4±29.8
PGM-7	1.10±0.02	1045.8±32.4
PGM-8	1.07±0.03	1102.4±36.7
PGM-9	0.94±0.04	976.4±36.8
PGM-10	0.82±0.03	875.3±37.5

Table S2. Comparison of the PV performance in this work with others

Membrane	Symbol	Temp. °C	Feed (ethanol wt %)	Water flux (kg·m^{-2}· h^{-1})	Separation factor	Ref.
PVA	△	40	90	0.280	104	[1]
PVA/ZIF-90	⊗	30	90	0.268	1379	[2]
PVA/SiO$_2$	◆	40	85	0.145	1026	[3]
PVA/GO	■	45	95	0.074	4281	[4]
CS/siloxane	⬡	20	90	0.47	2182	[5]
CS	●	40	96	0.004	2208	[6]
SA/4A	⟁	30	90	0.111	1866	[7]
SA/PVP/PWA	◁	27	90	0.100	1250	[8]
HA/SA/PAN	⬠	80	90	0.90	1130	[9]
PAA/PEI/PAN	⊞	50	85	1.00	100	[10]
PAA/PEI/PES	▷	40	85	0.47	350	[11]
PGM-0	★	30	95	1.21	1127	This work

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