Vortex fluidic mediated synthesis of TiO$_2$ nanoparticle/MXene composites

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Fig. S1. SEM images of TiO$_2$NPs/MXene drop cast on silicon wafer and oven dried at 60$^\circ$C, MXene VFD processing, rotational speed 5k rpm, tilt angle 45$^\circ$ and flow rate 0.75 mL/min. (a-e) TiO$_2$ NPs/MXene spheres. (f) TiO$_2$ NPs/MXene sheets.
Fig. S2. TEM and HRTEM images for TiO$_2$ NPs/MXene drop cast on a grid, MXene after 10 mins in a sonic bath (6 kHz) before VFD processing at rotational speed 5k rpm, tilt angle 45° and flow rate 0.75 mL/min.
Fig. S3. Account for TiO$_2$ particle size (109 nanoparticles) in TiO$_2$ NPs/MXene collected, as derived by HRTEM for MXene VFD processing, rotational speed 5k rpm, tilt angle 45° and flow rate 0.75 mL/min.

Fig. S4. Photos for (a) MXene in 30% H$_2$O$_2$ (0.5 mg/mL), (b) MXene in 30% H$_2$O$_2$ (0.5 mg/mL) after 10 mins in a sonic bath (6 kHz). (c-g) TiO$_2$NPs/MXene product outflow, derived from MXene VFD processing at flow rates 0.25 mL/min, 0.5 mL/min, 0.75 mL/min, 1 mL/min and 1.25 mL/min respectively, rotational speed 4k rpm and tilt angle 45°. (h-l) TiO$_2$NPs/MXene product outflow from MXene VFD processing, flow rate 0.75 mL/min, rotational speeds 5, 6, 7, 8 and 9k rpm respectively and tilt angle 45°.
Fig. S5. SEM images of material drop cast on silicon wafers and oven dried at 60°C. (a-c) MXene as prepared. (d-f) MXene in 30% H$_2$O$_2$ (0.5 mg/mL) after 10 mins in a sonic bath (6 kHz). MXene post VFD processing at rotational speed 4k rpm, tilt angle 45°, flow rates (g-j) 0.25 mL/min, (k-n) 0.5 mL/min, (o-r) 0.75 mL/min, (s-u) 1 mL/min, and (v-x) 1.25 mL/min.

Fig. S6. SEM images for TiO$_2$NPs/MXene drop cast on silicon wafers and oven dried at 60°C. VFD processing at tilt angle 45°, flow rate 0.75 mL/min with different rotational speeds, (a-c) 6k rpm, (d-f) 7k rpm, (g-i) 8k rpm, and (j-l) 9k rpm.
Fig. S7. EDS for TiO$_2$ NPs/MXene sphere drop cast on a silicon wafer and oven dried at 60°C, optimal VFD processing, tilt angle 45°, flow rate 0.75 mL/min, and rotational speed 5k rpm.

Fig. S8. EDS for TiO$_2$ NPs/MXene sheets drop cast onto a silicon wafer and oven dried at 60°C, MXene in 30% H$_2$O$_2$ (0.5 mg/mL) after 10 mins in a sonic bath (6 kHz) before optimal, tilt angle 45°, flow rate 0.75 mL/min, and rotational speed 5k rpm.
Fig. S9. SEM images for TiO\textsubscript{2} NPs/MXene drop cast onto silicon wafer and oven dried at 60°C, MXene in 30% H\textsubscript{2}O\textsubscript{2} (0.5 mg/mL) after 10 mins in a sonic bath (6 kHz) before VFD processing, tilt angle 45°, flow rate 0.75 mL/min, rotational speed 5k rpm. (a-c) Spheres after 25 days for the same sample. (d-f) Spheres after 60 days for the same sample.

Fig. S10. EDS mapping of stable TiO\textsubscript{2} NPs/MXene spheres drop cast on a silicon wafer and oven dried at 60°C, optimal VFD processing, tilt angle 45°, flow rate 0.75 mL/min, and rotational speed 5k rpm. The spheres are after 60 days of same preparation.
Fig. S11. Raman spectra for TiO$_2$ NPs/MXene spheres and sheets prepared from MXene optimal VFD processing, rotational speed 5k rpm, tilt angle 45° and flow rate 0.75 mL/min, after 60 days.
Fig. S12. SEM images in studying the stability of TiO$_2$NPs/MXene, MXene optimal VFD processing, tilt angle 45°, flow rate 0.75 mL/min, and rotational speed 5k rpm. (a-d) Drop cast material on a silicon wafer after 1 day, (e-h) after 3 days, (i-l) after 6 days, and (m-p) after 60 days.
Fig. S13. SEM image for material from control experiments. (a-d) MXene in water (0.5 mg/mL) after 10 min batch sonication (6 kHz) before delivering to the VFD at a flow rate of 0.39 mL/min, with 30% H₂O₂ added at the same time through a second jet feed at a flow rate of 0.39 mL/min, rotational speed 5k rpm, and tilt angle 45°. (e-h) MXene in water and 30% H₂O₂ volume ratio 5:1, concentration of MXene 0.5 mg/mL with the solution previously bath sonicated for 10 min (6 kHz), flow rate of solution was 0.75 mL/min, rotation speed 5k rpm, and tilt angle 45°.

Fig. S14. SEM images for TiO₂ NPs < 100 nm in diameter in 30% H₂O₂ (0.5 mg/mL) after optimal VFD processing, tilt angle 45°, flow rate 0.75 mL/min, and rotational speed 5k rpm.
Fig. S15. SEM images for (a-d) MXene in 30% H₂O₂ + DMF ratio 1-1, then 10 mins of bath sonication (6 kHz) before VFD processing, rotational speed 5k rpm, concentration 0.5 mg/mL, the flow rate 0.75 mL/min and tilt angle 45°. (e-h) Collected TiO₂NPs/MXene from the tube after rotating at 5k rpm, 0.75 mL/min, 0.5 mg/mL with a tilt angle of 45°, re-dispersed in 15 mL of DMF previously passed through the VFD, rotational speed 8k rpm, flow rate 0.75mL/min, tilt angle 45°. (i-l) MXene in 30% H₂O₂ (0.5 mg/mL) after 10 mins bath sonication (6 kHz) before passing through the VFD with another jet feed delivering DMF, tilt angle 45°, rotational speed 5k rpm and flow rate for both MXene in 30% H₂O₂ and DMF 0.38 mL/min.