# Environmentally Stable MXene Inks for Electrohydrodynamic Jet Printing of Micro-Electronics

**Shahzaib Ali [a],** Faisal Shahzad [c], Hassan A. Arafat [c, *], Dae-Hyun Cho [d, *], Doyoung Byun [a,b, *]

[a] *Department of Mechanical Engineering, Sungkyunkwan University (SKKU), 2066 Seobu-ro, Jangan-gu, Suwon-si, Gyeonggi-do 16419, Republic of Korea.*
[b] *Department of Display Engineering, Sungkyunkwan University (SKKU), Suwon 16419, Republic of Korea*
[c] *Research and Innovation Center for Graphene and 2D Materials (RIC2D), Khalifa University, Abu Dhabi, 127788, United Arab Emirates.*
[d] *Department of Mechatronics Engineering & Department of Energy System Engineering, Gyeongsang National University, 501 Jinju-daero, Jinju-si, Gyeongsangnam-do, Republic of Korea*

Contact: shahzaibali@g.skku.edu

Inkjet printing, a non-contact, direct patterning technique that forms designs by ejecting ink droplets, has gained significant attention in the fabrication of electronic devices requiring diverse pattern geometries. Electrohydrodynamic (EHD) jet printing, a more advanced variant of this technology, enables the deposition of high-viscosity inks exceeding several hundred cP, which is beyond the capabilities of conventional inkjet methods. This advancement allows for the formation of intricate, high-resolution patterns that are difficult to achieve otherwise. While photolithography remains the dominant patterning method in electronic device manufacturing, it requires multiple steps—such as coating, exposure, development, and subsequent drying or curing processes leading to extended production times and increased costs.

In contrast, inkjet printing simplifies the workflow, involving only the printing and post-processing stages, which significantly accelerates production and reduces costs. This method also eliminates the need for photoresist and developer, using only the necessary amount of material, making it both economically and environmentally sustainable. In this study, we optimized MXene ink, known for its exceptional conductivity and volumetric capacitance, for use in EHD jet printing. Given MXene's known vulnerability to oxidation under ambient conditions, we carefully evaluated its oxidation resistance. Additionally, we characterized the conductivity and pattern resolution of the printed electrodes to confirm their suitability for high-performance electronic applications.

## References

[1] Hu, G., et al., Functional inks and printing of two-dimensional materials. Chemical Society Reviews, 2018. 47(9): p. 3265-3300.
[2] Kamysbayev, V., et al., Covalent surface modifications and superconductivity of two-dimensional metal carbide MXenes. Science, 2020. 369(6506): p. 979-983.

## Figures

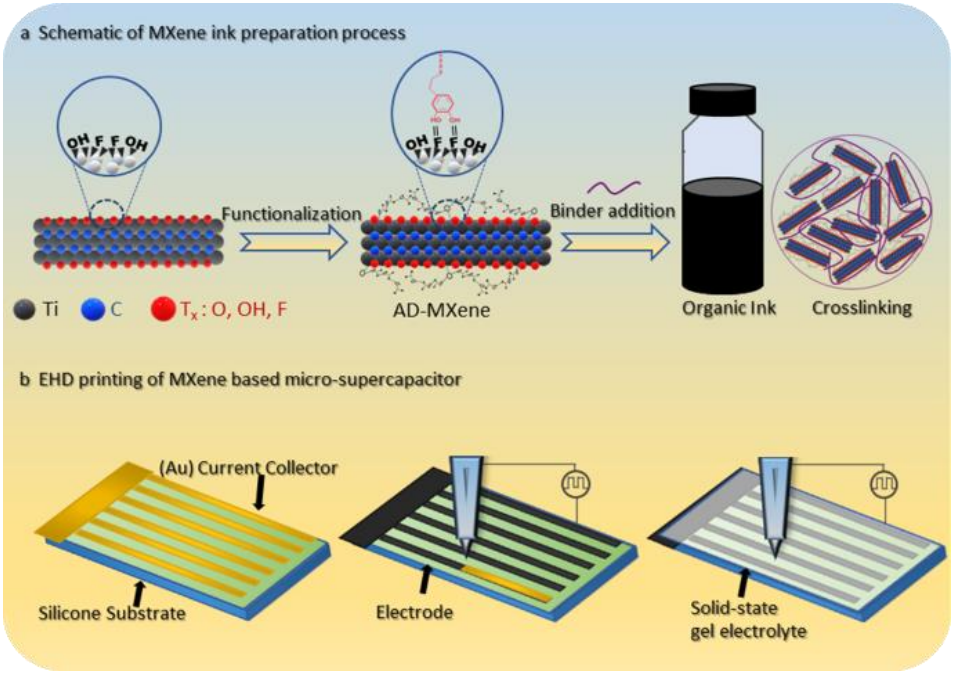


**Figure 1:** Schematic illustration of (a) environmentally stable MXene ink synthesis, and (b) EHD jet printing of micro electronic devices.