Highly sensitive and selective chemical sensing with functionalized 2D MoS_2: a supramolecular approach

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The relentless escalation of industrial and agricultural activities has resulted in a dramatic increase in diverse pollutants released into the environment worldwide.[1] To address such an environmental challenge, the development of new robust chemical sensors allowing the monitoring of the water composition efficiently and rapidly is highly sought after. Liquid-phase exfoliated two-dimensional (2D) transition metal dichalcogenides (TMDs) are suitable candidates for chemical sensing thanks to their high surface-to-volume ratio, sensitivity to the environment, unique electrical characteristics, and scalable processing.[2] However, pristine TMDs lack selectivity due to non-specific analyte-nanosheet interactions. To overcome this drawback, defect engineering enables controlled functionalization of 2D TMDs. Here, we develop ultrasensitive and selective MoS_2-based sensors for heavy metal Co^{2+} ions via the covalent functionalization of defect-rich MoS_2 flakes with a specific receptor, i.e. 2,2':6',2''-terpyridine-4'-thiol. A continuous network is assembled by the healing of MoS_2 sulfur vacancies in a tailored microfluidic approach, which guarantees high control over the assembly of thin and large hybrid films. The Co^{2+} cations complexation represents a powerful gauge for low concentrations of cationic species which can be best monitored in a chemiresisitive ion sensor, featuring a 1 pM limit of detection, sensing in a broad concentration range, high sensitivity combined with high selectivity towards Co^{2+} over K^+, Ca^{2+}, Mn^{2+}, Cu^{2+}, Cr^{3+} and Fe^{3+} cations. This supramolecular approach based on highly specific recognition events can be adapted for sensing other analytes such as ions and (bio)molecules through the ad-hoc design of the specific receptor.[3]

References

[1] L. Yu, L. Sun, Q. Zhang, Y. Zhou, J. Zhang, B. Yang, B. Xu, Q. Xu, *Biosensors*, 12 (2022) 1096.
[2] R. Furlan de Oliveira, V. Montes-García, A. Ciesielski, P. Samorì, *Mater. Horiz.*, 8 (2021) 2685.
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Figures

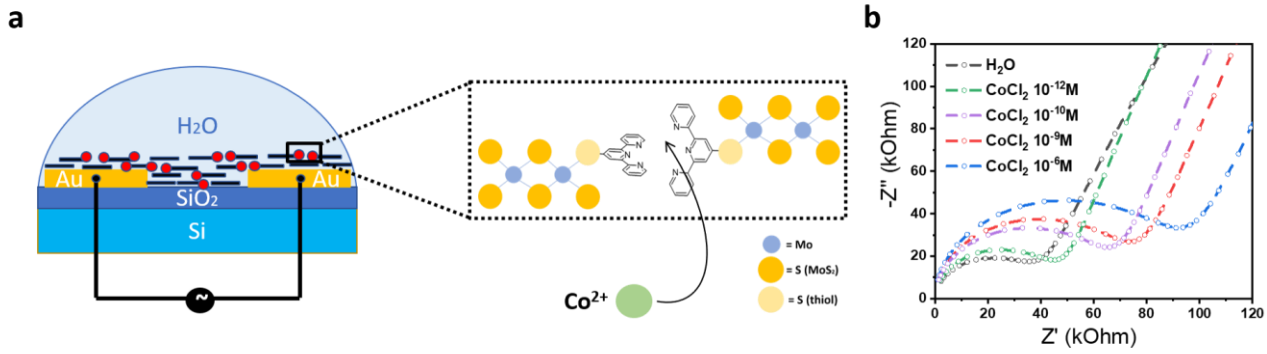

Figure 1: (a) Schematic representation of the device architecture. (b) EIS signal evolution upon Co^{2+} concentration increase.