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MoS_2 Transformation in Biomimetic and Biological Media Revealed by *In-situ* Liquid Phase STEM and *Ex-vivo* Studies

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In the booming of 2D materials for a variety of applications, transition metal dichalcogenides, in particular molybdenum disulfide, have raised as an attractive subject thanks to their exceptional electronic, optical, mechanical and chemical properties [1]. Notably, the large surface area with tunable electronic properties, the intercalable layers and the readiness for functionalization makes them good candidates for biomedical proposes such as biosensing, bioimaging, and drug delivery, among others. Furthermore, MoS_2 have shown to have a better biocompatibility and stability in comparison with their carbon-based analogues. Prior publications assessing the degradation products from the biotransformation of MoS_2 point to the oxidation of the sheets leading to the formation of free Mo^{+4} ions and molybdenum oxides [2]. Such degradation process appears to be innocuous for the cell life. Nonetheless, additional insight in the biotransformation mechanism of exfoliated MoS_2 nanosheets is key in the assessment of its viability for biomedical applications.

Herein, we have implemented a complementary approach by using *in situ* liquid phase transmission electron microscopy and *ex vivo* studies to unveil a new aspect of the behavior of MoS_2 patches in conditions mimicking those within cells, in particular those with high concentrations of ROS and H_2O_2. We have observed in direct the scrolling of MoS_2 sheets in situ and verified the presence of the same structures e*x vivo* (Figure 1-2). Additionally, we determined that freestanding unrolled sheets can undergo oxidation and etching. The oxidized fragments were found in post-in situ samples and extra-cellular vesicles recovered from ex vivo experiments. Further studies enquiring on the effect of the scrolling in the stability of the nanoscrolls should be conducted in order to prove that this can constitute a protective mechanism of the structure. We would like to acknowledge the financial support of the French national research agency for the CYCLYS project.

References:

[1] K Bazaka *et al*, J Phys D Appl Phys **51** (2019), p. 1.
[2] R Kurapati *et al*, Adv Funct Mater **27** (2017), 1605176.

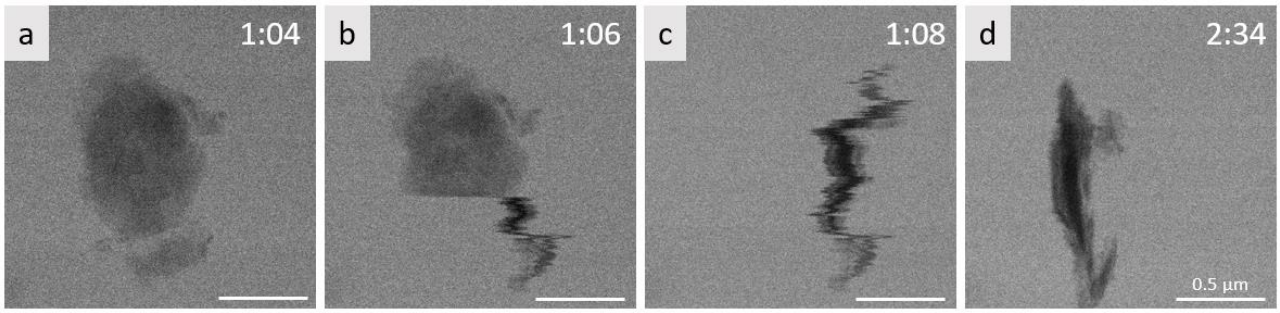

Figure 1. Image sequence from *in situ* liquid phase recording of MoS_2 patch scrolling in a 5 mM H_2O_2-DPBS.

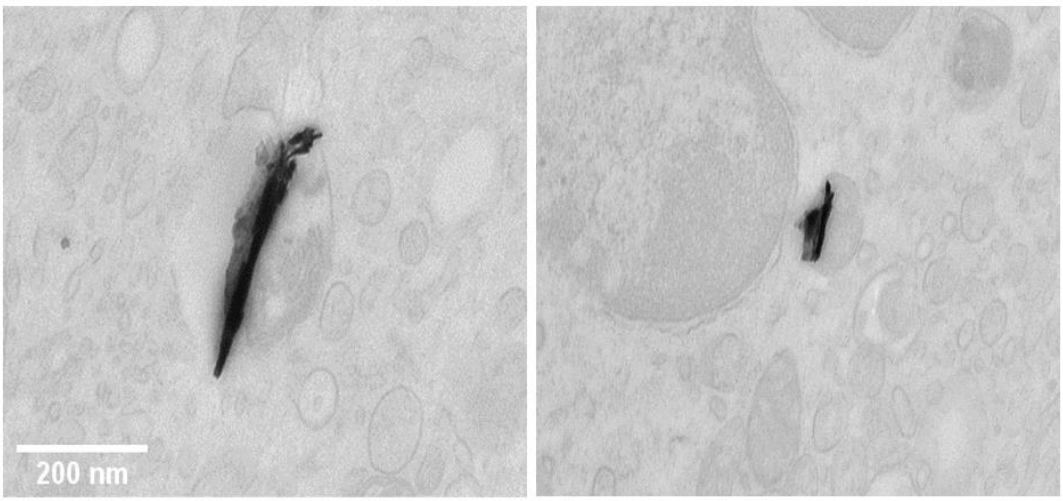

Figure 2. Cell slices from *ex vivo* experiments displaying scrolled sheets imbedded within inner cellular structures after 48h.

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