

# Liquid-exfoliated transition metal dichalcogenides: from spectroscopic metrics to Functionalisation

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Liquid exfoliation has become an important production technique to give access to large quantities of two-dimensional nanosheets in colloidal dispersion.<sup>[1]</sup> Importantly, this is a highly versatile technique that can be applied to numerous layered materials beyond graphene. These can be cast into films and composites and have proven useful in a number of application areas. However, as produced dispersions contain a nanosheets of various sizes and thicknesses making post-exfoliation size selection extremely important to tap the full potential in the future. We have previously developed a universal and efficient size selection technique termed liquid cascade centrifugation<sup>[2]</sup> which allowed us to produce monolayer-rich dispersions with monolayer volume fractions up to 75%. Optimisation was made possible because we have realised that nanosheet size and thickness, as well as monolayer content can be quantitatively extracted from optical spectra due to edge and confinement effects greatly facilitating and accelerating the characterisation.<sup>[2,3]</sup>

We now use this basic understanding and these improvements in sample quality to systematically investigate the effect of the chemical environment on the optical properties of the liquid-exfoliated nanosheets.

For example, we show that the A-exciton energy depends on the layer number in a similar way for a number of different TMDs. Furthermore, dielectric screening from additives and solvents can be tracked via this A-exciton layer number dependence making this an ideal fingerprint for noncovalent functionalisation. Last but not least, we show that the ability to dramatically increase the surface area of the layered materials on exfoliation can be used to explore new chemistry and to controllably functionalise either basal plane<sup>[4,5]</sup> or edge sites (Figure 1).

## References

- [1] *Adv. Mater.* **2016**, 28, 6136-6166.
- [2] *ACS Nano* **2016**, 10, 1589-1601.
- [3] *Nature Commun.* **2014**, 5, 4576.
- [4] *Angew. Ch. Int. Ed.* **2015**, 54, 1-6.
- [5] *ACS Nano* **2015**, 9, 6018-6030.

## Figures

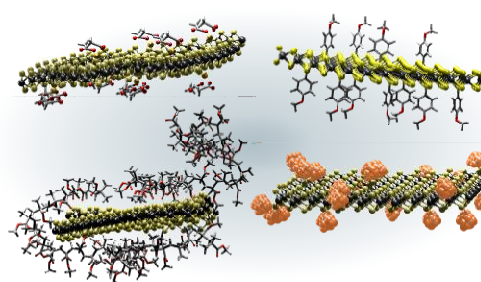


Figure 1. Schematics of functionalized transition metal dichalcogenides via various strategies