Carbon quantum dot/CuS\textsubscript{x} nanocomposite towards high efficient lubrication and metal wear repair

Supporting Information

Figure S1. Photo image of figure for the mass preparation product (0.25 kg/h) of CQDs/CuS\textsubscript{x} nanocomposites.

Figure S2. The size distribution of CQDs/CuS\textsubscript{x} nanocomposites.
**Figure S3.** The FTIR spectrum of CQDs/CuS\textsubscript{x} nanocomposites.

**Figure S4.** The TEM image (a) and size distribution (b) of CuS\textsubscript{x} nanoparticles.
Figure S5. Photographs of CQDs/CuSₓ soaked in liquid paraffin (a, 5.0 wt %; b, 10.0 wt %) at different time periods, showing the dissolution process.

Figure S6. UV-Vis spectra of liquid paraffin with or without CQDs/CuSₓ.
**Figure S7.** The amplified variation of friction coefficient with different contents (0-1.0) of CQDs/CuS\textsubscript{x} nanocomposites in liquid paraffin.

**Figure S8.** The effects of different components on antiwear abilities with liquid paraffin, CQDs, CuS, CQDs and CuS\textsubscript{x} mixture, and CQDs/CuS\textsubscript{x} nanocomposites as additives, respectively.

**Figure S9.** The designed device to understand the effect of CQDs/CuS\textsubscript{x} nanocomposites on the lubrication and repair of worn surface behaviour. Stainless steel 304L is used as frictional couple.
Figure S10. (a) SEM image of CQDs/CuS$_x$ nanocomposites on the repair of worn surface and the corresponding EDS elemental mapping images of (b) Fe, (c) Cu and (d) S.

Figure S11. (a) SEM image of CQDs/CuS$_x$ nanocomposites on the repair of worn surface and the corresponding EDS elemental mapping images of (b) Fe, (c) Cu and (d) S.
Figure S12. Typical full-survey XPS spectrum of CQDs/CuS\textsubscript{2} nanocomposites on repair of worn surface.
Figure S13. The friction coefficient without CQDs/CuS<sub>x</sub> nanocomposites (a), with (b) and after insertions 1000 times (c) under compression and extension.
Figure S14. The variation of automobile exhaust after using CQDs/CuS$_x$ nanocomposites as additive.