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Understanding in vivo reactivity of metal orthopaedic implants

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CoCr alloys became commonly used in orthopaedic implants, especially for younger patients, owing to their superior wear and corrosion resistance. However, severe inflammation resulted in unexpectedly high failure rates, leading to the withdrawal of some CoCr devices from the market, and lawsuits were filed in the US. Simulation studies show that, despite exhibiting lower volumetric wear, CoCr implants produce more, smaller (50 nm-3 µm), particles; up to *one trillion nanoparticles (NPs)* can be produced in each patient annually. The observed inflammation in patients is believed to be caused by these wear-produced NPs. CoCr NPs have been observed in macrophage cells in periprosthetic tissue. While CoCr is extremely corrosion resistant in bulk form, Co^{2+} ions have been observed in blood and other organs such as the liver and spleen raising question on the mechanism of the dissolution of the CoCr NPs particles *in vivo*.

Ex situ studies of CoCr NPs in simulated biological environment have been performed in our lab with the use of an applied electrochemical potential to simulate the oxidising environment generated during inflammatory response. Electron microscopy revealed morphological changes in the particles as they developed into a porous sponge-like structures (*e.g.* shown in Figure 1). This phenomena has not been observed in CoCr alloys before, revealing a new mechanism of dissolution of these alloys at the nanoscale. This research suggests that new testing criteria are required for implant materials, in particular where there is wear debris generated, where *bulk* form testing must be accompanied with studying reactivity of materials at the nanoscale.

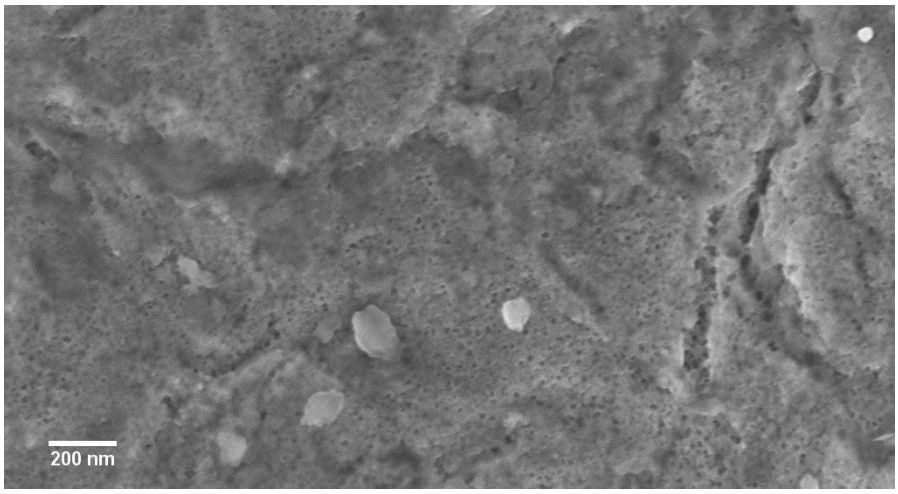

Figure 1. *Scanning electron microscopy image of the surface of CoCr particle after being polarised at 0.75V (vs Ag/AgCl) in simulated biological fluid.*