An electrically conducting water-based reversible adhesive

The Problem

In 2022, the total amount of electronic waste (e-waste) produced globally was 62 billion kilograms (62 billion kg). This is due to the combination of high demand, rapid technological improvement, and insufficient recycling efforts, leading to a growing e-waste crisis, with less than 25% of e-waste being recycled properly. E-waste poses a serious threat to human health and the environment due to the presence of hazardous materials, such as heavy metals and toxic substances, which have the potential to leach into the environment and cause serious harm if not disposed of properly that needs complex consideration during end-of-life management to minimise the impact on human health and environment. E-waste should be integrated into a circular economy by returning it to the production chain through reuse and recycling, as it contains valuable metals that can help minimise the demand for virgin mining of rare metals.

Our Solution

A reversible conductive adhesive (RCA) has been developed by researchers at Newcastle University, with the aim, for example, of allowing electronic components to be easily removed from printed circuit boards. The glue is a water-based emulsion based on nanoparticles of poly(styrene-co-butyl acrylate) (PStBA). These particles are stabilised by poly(acrylic acid) (PAA), as depicted in Figure 1, which is grown from the nanoparticles. Such formulations readily form films when coated (painted) onto a surface, and when two such surfaces are brought together, they adhere. Adhesive reversibility can be achieved using chemical stimuli (pH change). The charge on the carboxylic acid groups (-COOH) in PAA can be controlled by pH. At higher pH (above its pKa ≈ 4.5), deprotonation of carboxylic groups occurs, and adhesion fails.

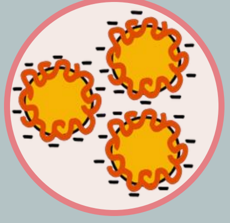

Figure 1. Emulsion particles stabilised by a polyanion.

This adhesive fails at alkaline conditions without leaving residue on the substrates hence eliminating the need for an additional washing stage requiring organic solvents such as acetone or paint thinner.

When filler, such as silver nanoparticles, was added to these formulations, the films were observed to conduct with low resistivity (3.5×10^{-4} Ω.cm) at a filler loading of 16 vol.%. The RCA was tested on surfaces, such as copper and aluminium, which show good reversibility and adhesion strength reaching up to 2.2 MPa. The reversibility of the adhesive has several unique properties that set it apart from other adhesives. It can be debonded on demand without causing significant damage to the materials involved, allowing for the recycling and reuse of materials.

RCAs can provide multi-functional properties with broad applications:

- Bonding capabilities even on non-solderable substrates like glass.
- The high thermal conductivity makes them useful for applications requiring heat dissipation.
- Highly flexible, making them useful for bonding materials that undergo thermal expansion and contraction.
- Can withstand chemical, corrosion, and environmental degradation.

The Opportunity

The RCA can simplify the recycling process, reduce associated costs, and enhance overall efficiency, leading to a more sustainable electronic lifecycle.

Additionally, the RCA can help offset the increasing demand for virgin mining of essential metals by recycling valuable resources in e-waste. At the same time, adhesive can be produced from renewable sources with minimal environmental impact at a reasonable cost.

A UK PCT patent application has been filed (P380076GB).

The University is seeking collaborative opportunities.

Newcastle University

Contact:
Dr Timothy Blackburn, Business Development Manager
Tel: +44 (0)7784 361143
Email: Tim.Blackburn@ncl.ac.uk