



The Problem

Adhesives are materials used in all types of manufactured products and though their use is widespread, their presence is often underestimated. Traditional adhesives pose significant challenges due to their permanent nature, which complicates component separation, reusability, and recyclability. They often lead to contamination in recycling processes, increased waste, and limitations in product disassembly for repair or repurposing. Besides, most adhesives contain not only polymers, but other chemicals that may be harmful or hazardous, such as volatile organic compounds.

In this context, water-based adhesives are to be preferred as an environmentally friendly alternative to conventional solvent-based adhesives. However, they usually face the following challenges:

- Inferior performance particularly under humid conditions.
- Recovery of the previously bonded materials.

Our Solution

Researchers at Newcastle University have developed a water-based adhesive through emulsion polymerisation that is reversible in alkaline media ($\text{pH} \approx 14$). The system consists of polymer particles coated with poly(acrylic acid), a polyanion, and contains montmorillonite clay. Figure 1 shows typical polymer emulsion particles with a hydrophobic core and polyanionic shell.

Emulsion polymerisation allows the use of inexpensive commodity materials, is scalable, and is already used in industrial processes. In addition, clays have been historically used as thickening agents, and montmorillonite, being highly hydrophilic and negatively charged, is compatible with the polyanionic emulsion.

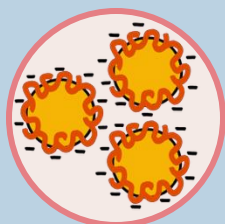


Figure 1. Emulsion particles stabilised by a polyanion.

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. Figure 2 shows the polyanionic-clay adhesive, PET and PP plastic substrates after reversibility has occurred.

Reversibility was first demonstrated to take 24 h at room temperature and static conditions (no stirring). However, the process can be sped up to less than 1 h when stirring at 85° C at conditions determined by plastic recycling protocols.

The adhesive can bind to various substrates such as glass, metals, common plastics and other challenging substrates (i.e., low surface energy surfaces) like polypropylene. Lap shear strength measurements show values of up to 1.5 MPa, comparable to commercial white PVA glue, but with the advantage that its superior adhesive properties for plastics and its reversibility offers.



Figure 2. Representative reversible behaviour of polyanionic-clay formulation in alkaline conditions.

The reversible adhesive is versatile. Polycationic emulsions where poly(acrylic acid) is exchanged by a polycation can also be produced and combined with positively-charged hydrotalcite clay to improve its rheological, reversibility and adhesive properties.

The Opportunity

An adhesive showing these characteristics is critical for recyclable products, e.g., bottles and labels. Currently, plastic bottle de-labelling involves several steps employing friction, an abundance of water and compressed air. Due to unreliable adhesive removal which subsequently makes labels unrecyclable, waste labels are primarily landfilled, contributing significantly to land and water pollution.

Other industries such as packaging, EV batteries or e-waste managing requiring dismantling and repurposing of parts would also benefit from this adhesive technology.

Two patent applications for this technology have been filed (WO 2024/084210 A1 and PCT/GB2025/051976)

The University is seeking collaborative opportunities.



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