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Selectively (dis)assembly of vitrimer-based flexible electronics

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Thermosets are widely used as substrates in electronics due to their superior thermomechanical properties and chemical resistance [1]. Among them, polybenzoxazines are gaining attention for applications such as printed circuit boards, encapsulants and potting compounds [2] owing to their moisture resistance and electrical properties [3]. However, like other thermosets, polybenzoxazines are non-recyclable which raise significant concerns regarding resultant electronics waste [4]. This study addresses the issue at the molecular level by developing new benzoxazine-based vitrimers intended for flexible electronic applications. The strategy applied involves designing both single and dual exchange materials to enable their assembly via welding followed by a selective chemical disassembly. In support of this, a flexible precursor containing only ester bonds along with a rigid substrate containing both disulfide and ester bonds were synthesized. Their thermomechanical, and vitrimeric properties were assessed after crosslinking and selective disassembly tests were conducted between the two different substrates. The rigid dual exchange vitrimers was subsequently employed as a substrate for device fabrication by physical vapor deposition (PVD), where copper was deposited to produce a resistance temperature detector (RTD). This metallic deposition was encapsulated by hot-pressing the flexible single exchange on the rigid dual exchange substrate, demonstrating the ability of assembling dissimilar materials while protecting the deposition. The final device was employed as a temperature sensor whose substrate and encapsulant chemistries enable selective chemical disassembly. This work marks a step towards the design of more sustainable electronic devices, addressing the growing challenge of electronic waste.

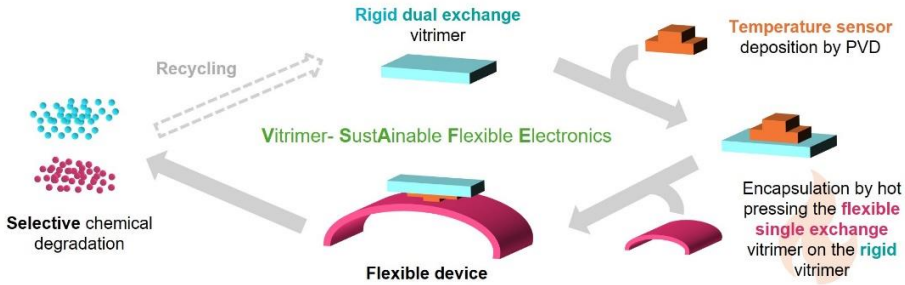

Figure 1: Lifecycle of a temperature sensor deposited on a rigid vitrimer and protected by a flexible vitrimer (applied by hot-pressing), with differences in the chemistry of the two vitrimers enabling selective chemical degradation.

References:

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[2] Rimdusit, Ishida, Development of new class of electronic packaging materials based on ternary systems of benzoxazine, epoxy, and phenolic resins, Polymer, 41 (22), 7941-7949, 2000, DOI: 10.1016/S0032-3861(00)00164-6.

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