Hydrothermal Oxidation: The Next Generation for Abatement of Unrecyclable Waste of Hazardous Nature and Complex Composition

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Hydrothermal oxidation is an advanced technology, best applied for the destruction of unrecyclable, chemically stable, non-biodegradable wastes of diverse composition. They are predominantly hazardous and can cause significant threat to human health, wildlife, and the environment as a whole. They comprise chemical, pharmaceutical, petrochemical, construction, mining, batteries, circuit boards and electronic-related processes. In many industries, the sludge remaining after treatment of wastewater accounts for much of the generated hazardous waste due to the non-removable, potentially toxic elements (PTEs). They can also be residues from agriculture to domestic households. With the escalating problem of hazardous wastes worldwide, hydrothermal oxidation in supercritical water (SCWO), offers an excellent alternative to incineration and landfill, which are the current techniques for unrecyclable waste disposal. *The aim of this work is to link water chemistry to operational behaviour and its impact on process design.*

This work relates the intermolecular structure and thermophysical properties of supercritical water (SCW) to its operational behaviour, leading up to the main design considerations of the SCWO process. Starting with a conceptual process description, it highlights the roles of feedstock nature, reactor design and energy integration scenarios and their effects on the process performance.

Furthermore, it illustrates two approaches to enhance the SCWO process: multi-port oxidant injection, and addition of a co-fuel (isopropyl alcohol (IPA) in this case) to improve ammonia removal, as recalcitrant N intermediate. Theoretically, kinetics investigations in the presence and absence of IPA are shown, to highlight its influence of the rate expression. The effect of IPA on organic carbon removal (TOC) and nitrogen removal (N) is kinetically modelled and experimentally validated. Reaction rate constants, activation energies and reaction rate expressions are presented. Reaction mechanisms are also proposed.