OST Ostschweizer Fachhochschule

UMTEC Institut für Umwelt- und Verfahrenstechnik

The Institute of Environmental and Process Engineering UMTEC consists of three specialist groups: Recycling and Process Engineering, Water and Wastewater Engineering and Advanced Materials&Processes. Around 15 scientists and engineers from the fields of mechanical and process engineering, environmental sciences and chemistry are engaged in research and development projects.

The Recycling and Process Engineering group is specialized in the mechanical processing of secondary raw materials. In a uniquely equipped process engineering laboratory, we develop processes and equipment for the separation of bulk materials and for phase separation. We draw on many years of experience from numerous projects with industry and environmental agencies. Around 40 patents are proof of our innovative potential.

Our eight employees in the field of recycling and process engineering are mainly engineers from OST and ETH Zurich. They are supported by interns and students.

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"We don't study technical problems. We solve them!" UMTEC

VinylAcid

hydrochloric acid produced from non-recyclable PVC wastes

Background

For metal recovery, about 2/3 of the fly ash from waste incineration plants (WIPs) in Switzerland is subjected to acid washing in the FLUWA process. The acid required, mainly hydrochloric acid (HCl), is generated by scrubbing the flue gases from MWIs and replaces "technical grade" HCl. About half of the HCl recovered in the flue gas scrubbers is produced by burning "natural" PVC in the waste. Acid washing of fly ash will be mandatory in Switzerland from 2026. The amount of acid produced in the Swiss MWI is not sufficient to wash all Swiss fly ash, so technical grade HCl would have to be purchased. In the VinylAcid project, non-recyclable PVC sorting residues were added to the feed of an MWI equipped with a flue gas scrubber. This increased the amount of HCl produced and eliminated the need for FLUWA plants to purchase technical grade HCl. In addition, old PVC waste often contains heavy metals such as lead and cadmium, which prevent mechanical recycling. However, when added to a MWI, they report to the fly ash and are thus recovered by the FLUWA process. In the Euro zone, most MWIs employ dry flue gas cleaning and the resulting fly ash is deposited in underground landfills. Acid recovery and heavy metal extraction are not technically feasible in such plants. However, if such waste is sent to waste incinerators with flue gas scrubbing and FLUWA, not only can HCl production be increased, but the heavy metals contained can also be recovered. This "chemical" recycling of PVC into hydrochloric acid is a potential complement to mechanical recycling of PVC.

Field Trials

In two field trials at the MWI Thun in August 2021 and March 2022, PVC sorting residues were mixed with normal waste and incinerated during normal operation. In the first experiment, 40 t of plastic sorting residues with a low chlorine content (chlorine content approx. 3%) were added over 5 days. In field trial 2, a total of 80 t of high chlorine waste (chlorine content approx. 20%) was added over 17 days.

Fig. 1 Left: Sorting residues from plastic sorting for field trial 1. Right: PVC floor cuttings for field trial 2.

Results

The chlorine content of the "normal waste" without additional PVC was determined to be about 0.7%. The addition of PVC increased the chlorine content by about 20% in field trial 1 and 30% in field trial 2. Compared to the respective reference period 8 weeks before the tests, the average daily acid production increased by 33% in the first experiment and by 45% in the second experiment. The chlorine balance of the incineration residues showed that virtually all the chlorine added to the waste by the addition of PVC is actually converted to hydrochloric acid.

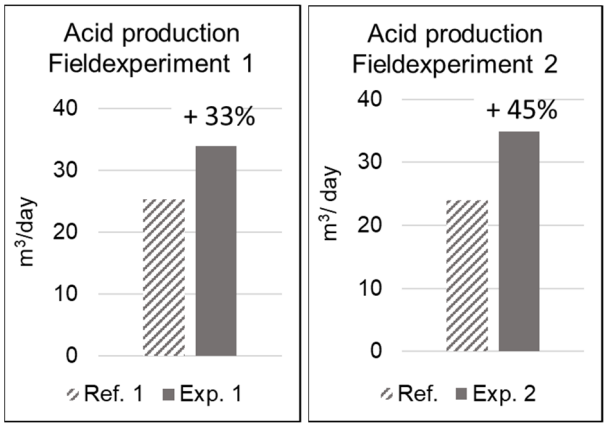

Fig. 2: Increase in acid production during the field trials compared to normal operation without PVC dosing.

The concentrations of volatile heavy metals in the fly ash were higher in both tests than during normal operation. The additional chlorine in the waste appears to have formed more volatile heavy metal chloride compounds, transferring these heavy metals from the bottom ash to the fly ash. This effect is very beneficial as the water or acid soluble heavy metals are subsequently extracted from the fly ash in the FLUWA process and recycled.

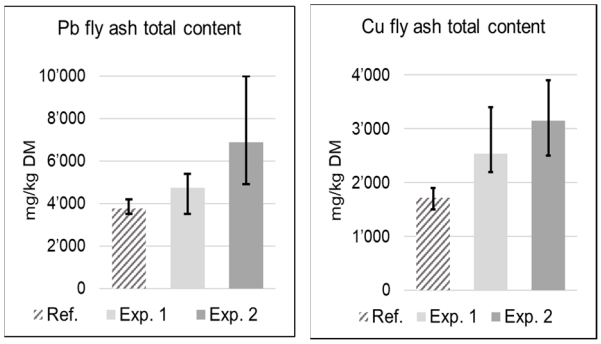

Fig. 3: Total heavy metal contents in the fly ashes during the field trials compared to the baseline reference in normal operation without PVC addition.

Dioxin concentrations in the fly ashes were not monitored in detail but appear to have increased by some 30% during the experiments. An inspection of the MWI Thun immediately after field trial 2 did not reveal any increased corrosion that could be related to the experiments. Since corrosion occurs mainly under deposits on iron parts, the corrosion rate in waste incineration is not directly dependent on the HCl concentration in the flue gas. It is therefore expected that a moderate increase in the chlorine content of the waste by e.g. 50% will not lead to accelerated corrosion. In the early stages of incinerator operation, the formation of deposits on the heat exchangers is indeed due to chlorine, but this process is inevitable and not specific for the VinylAcid process. Chlorine is a natural component of municipal waste, so corrosion is chlorine specific, not PVC specific.

Conclusion

The proof of concept for the chemical recycling of chlorine and heavy metals from PVC sorting residues (VinylAcid process) has been achieved. The incineration of moderate amounts of additional PVC in a MWI with flue gas scrubbing is well controlled and the acid produced is increased in proportion to the PVC addition. The addition of chlorine and heat results in enhanced transfer of volatile heavy metals from bottom ash to fly ash, from which they are recovered by acidic fly ash washing.

VinylAcid is a welcome complement to mechanical PVC recycling from two perspectives:

- Environmentally: The process conserves primary resources by increasing the transfer of volatile heavy metals to the fly ash and recovering these heavy metals through FLUWA. The acid replaces technical HCl, the production of which consumes energy and resources. In addition, the bottom ash is depleted of soluble heavy metals, which improves the quality of the bottom ash.

- Economically: The acid produced replaces expensive technical grade HCl, and more recycled heavy metals increase revenues. An additional source of income for MWI is the gate fee for the non-recyclable PVC sorting residues. In the EU, large quantities of old PVC waste containing heavy metals are still being collected. This material cannot be mechanically recycled, but it can be chemically recycled including the recovery of the contained lead.

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