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THERMOANALYTICAL CONTROL OF PAINT-SHOP WASTES PRIOR TO DISPOSAL

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The paint-shop wastes under study originated from metallurgical factory painting houses. Displaying a high toxicity and flammability, they are classified as specifically hazardous to the natural environment. Paint-shop wastes can be disposed of in the following ways:

- solidification and deposition in sanitary landfills;
- storage on a special dumping ground;
- incineration.

This paper presents the physicochemical composition and thermal analysis (DTA and TG) of paint-shop wastes and their mixtures with various components.

Thermoanalytical measurements were carried out in a dynamic atmosphere of air. Enthalpies were calculated from the peak areas of the DTA curves. Thermoanalytical data were compared with calorimetric results obtained with an oxygen bomb.

Keywords: environment, paint-shop wastes

Introduction

In environmental engineering, the application of thermal analysis (TA) is usually restricted to determination of the biological stability of various sewage sludges [1], their chemical characterization [2] and classification [3]. Thermoanalytical investigations of some industrial sludges were presented by Sebastian [4]. TA has been applied in the quality control of various types of lacquers and paint [5] and in the characterization of aged paint films [6]. The wastes from paint-shops belong in the group of hazardous wastes known to create particular environmental problems.

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Experimental

The following wastes were investigated:

* the mixture of "wet" wastes coming from the bottom of several painting cabins;

* the mixture of "dry" wastes coming from the walls and floors of such cabins;

* prepared mixtures of the above-mentioned wastes with other inflammable waste materials produced in the same plant.

The compositions of the mixtures (in wt.%) were as follows:

Components	Mixture				
	A	B	C	D	E
"Wet" wastes	60	60	80	80	80
"Dry" wastes	5	5	5	5	5
Sawdust	10	20	5	–	5
Oil-polluted textiles	15	–	5	10	–
Spent oil	10	15	5	5	10

The physicochemical analysis of the wastes was carried out according to Polish standards. Thermoanalytical curves were taken on an OD-102 derivatograph (MOM, Hungary). All experiments were conducted under identical conditions: after a drying procedure at 378 K, samples were heated up to 1273 K in platinum crucibles in an air atmosphere at a heating rate of 10 deg·min^{-1}, the reference material being α–Al_2O_3. The standards recommended by the Standardization Committee of ICTA [7] were applied for calibration of the apparatus. Enthalpies of reactions (ΔH_{DTA}) were calculated by the Simpson method of numerical integration of DTA curves.

The heats of combustion (ΔH_{comb}) were determined in a KL-5 bomb calorimeter (Precyzja, Poland).

Results and discussion

The physicochemical compositions of the investigated wastes are presented in Table 1. The observed differences are caused by lime-milk treatment in the case of "dry" wastes and by a higher content of painting materials and scale in the case of the "wet" ones. The DTA and TG curves in Fig. 1 are in good agreement with the physicochemical compositions of the wastes.

The thermal decomposition of "wet" wastes is characterized by a distinct exothermic effect in a wide range of temperature (from 433 K to 1063 K). The

Table 1 Physicochemical composition of paint-shop wastes

Waste	Weight loss		SiO_2 + part. insol.	Metal content /% dry solid				
	at 378 K /%	at 823 K /%	in strong acids (% dry solids)	Ca	Fe	Pb	Cr	Zn
"Wet" wastes								
from a bottom of painting cabin	61.5	46.9	23.2	1.83	8.67	2.37	2.56	3.82
"Dry" wastes								
from walls and floors of painting cabin	3.2	38.6	20.0	11.32	4.04	4.21	1.42	1.94

greatest weight loss occurs between 443 K and 623 K, amounting to 11,4%. The maximum decomposition is found at 533 K. From there the process takes place more slowly, to yield a total weight loss of 42.9%.

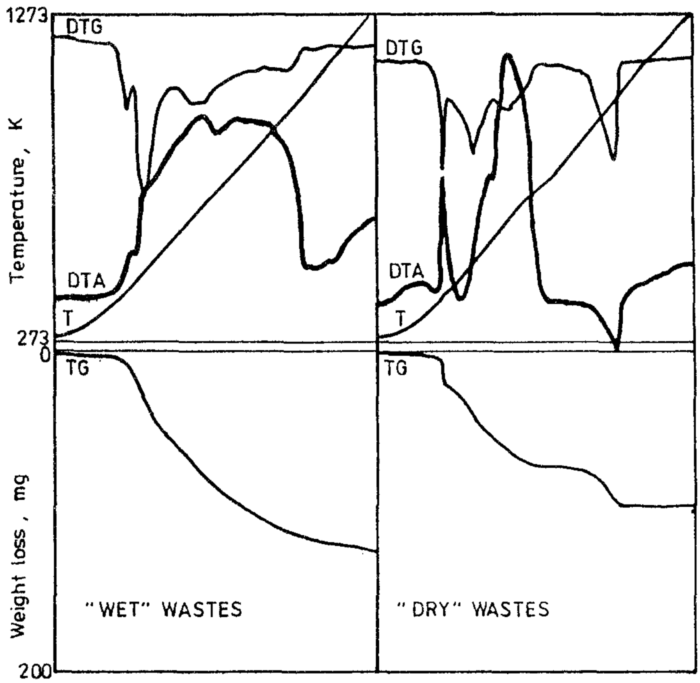

Fig. 1 Thermal decomposition of paint-shop wastes

In the initial stage of thermal decomposition of "dry" wastes, there is a rapid exothermic reaction with a relatively low weight loss at 468 K. It may be caused by the oxidation of low-boiling components of the painting material (not used in all types of cabins). A significant exothermic process occurs in the temperature range 518–823 K, and is followed by an endothermic reaction connected with the decarbonization of $CaCO_3$. The total weight loss amounts to 44,6%.

The heats of combustion of wastes are listed in Table 2; they amount to 9.44 and 8.05 kJ/g dry solid for the "wet" and "dry" wastes, respectively. In order to increase the calorific values of disposed wastes and to improve their consistency by decreasing the average water content, mixtures of wastes with other waste materials were tested. The thermal decomposition curves and the measured calorific values are shown in Fig. 2 and Table 2, respectively. The heats of combustion for inflammable components were as follows: sawdust – 19.65 kJ/g, cotton textile – 24.30 kJ/g, spent oil – 47.86 kJ/g.

On addition of 35% inflammable substances to paint-shop wastes, the total weight loss of mixtures A and B increases by 56.1% and 87.7%, respectively. The

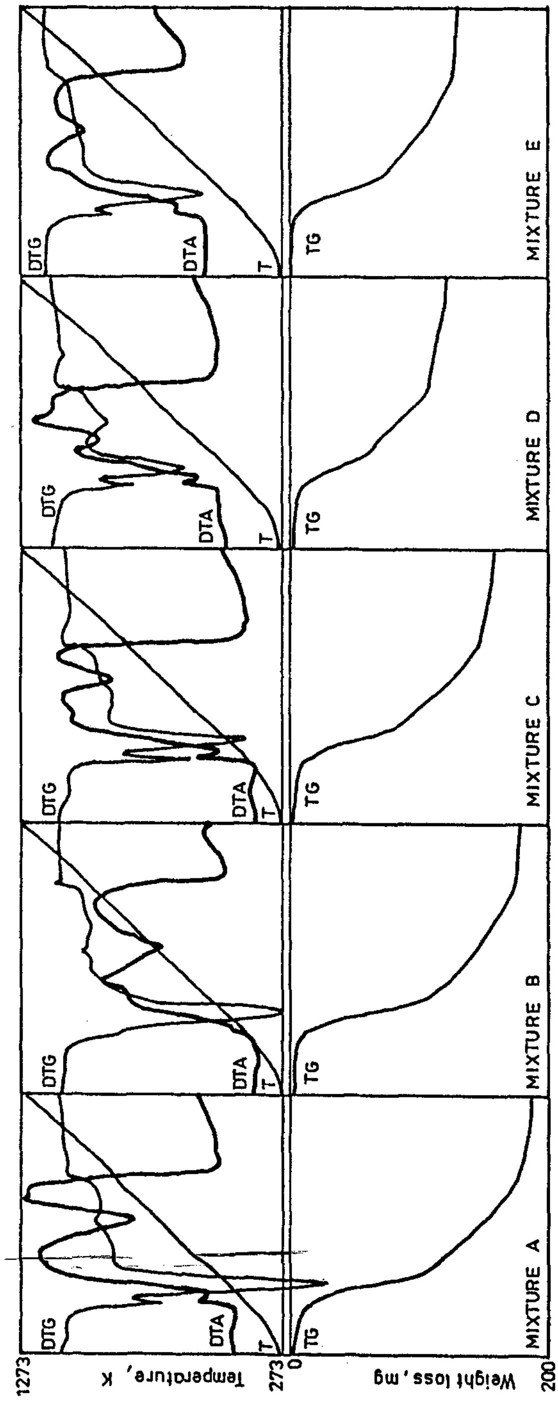

Fig. 2 Thermal decomposition of paint-shop wastes mixtures

heats of combustion increase from 61.2% to 166.3%. Better results were obtained for mixture B, where 20% of sawdust and 15% of spent oil had been added.

Table 2 Results of enthalpy measurements

Waste	Total weight loss at 1273 K / % dry solids	ΔH_{comb}/ $kJ \cdot g^{-1}$	ΔH_{DTA} / $kJ \cdot g^{-1}$	$\frac{\Delta H_{comb}}{\Delta H_{DTA}}$
"Wet" wastes	42.9	9.44	8.79	1.1
"Dry" wastes	44.6	8.05	5.38	1.5
Mixture A	67.1	15.04	9.56	1.6
Mixture B	80.7	24.85	10.82	2.3
Mixture C	63.5	14.68	10.56	1.4
Mixture D	58.0	13.78	9.82	1.4
Mixture E	63.7	17.52	11.98	1.5

On the addition of only 15% of inflammable components, the total weight loss and heats of combustion increase on average by 43.6% and 63.7%, respectively.

Because of their high calorific values, all types of investigated mixtures were classified for disposal by combustion. The best results were obtained on the addition of sawdust and spent oil.

The courses of the DTA curves show that the thermal behaviour of the mixture depends on the decomposition of the main component, raw paint-shop wastes. The narrower and sharper the decomposition peak for a particular component (spent oil > sawdust > cotton), the higher will be its contribution to the overall effect.

For all mixtures, the areas of DTA peaks are similar in opposition to measured values of ΔH_{comb}. A significant discrepancy was noted for mixtures with a higher concentration of spent oil due to its highest value of ΔH_{comb}. However, as compared with other data [4], the values of $\Delta H_{comb}/\Delta H_{DTA}$ for the investigated wastes are not particularly different from each other (1.4–2.3).

Conclusions

The combustion of paint-shop wastes together with a number of other inflammable waste materials produced in the same plant can be suggested as the most successful means of their disposal.

TA determination of the plots of the decomposition process, the final temperature, the corresponding weight loss and the calorific values provides valuable data on the suitable mode of preparation of wastes prior to their combustion.

Despite the heterogeneity and complex compositions of the investigated materials, their similar character allows determination of the correlation between ΔH_{comb} and ΔH_{DTA}. An accurate correlation coefficient could be calculated from a larger number of experiments.

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Zusammenfassung — Die untersuchten Lackier-Abfälle kommen aus Lackierereien metallurgischer Fabriken. Wegen ihrer hohen Toxizität und Entflammbarkeit werden sie für die natürliche Umgebung als besonders gefährlich eingestuft. Lackiererei-Abfälle können auf folgende Weise entsorgt werden:
- Verfestigung und Deponierung auf Ablagerungsplätzen
- Lagern in Sondermülldeponien
- Veraschung

In diesem Artikel wird die physikochemische Zusammensetzung und die Thermoanalyse (DTA und TG) beider Lackiererei-Abfälle und ihrer Gemische mit verschiedenen Komponenten beschrieben.

Die thermoanalytischen Messungen wurden in dynamischer Luftatmosphäre ausgeführt. Die Enthalpiewerte wurden anhand der Peakflächen der DTA Kurven berechnet. Die thermoanalytischen Angaben wurden weiterhin mit den kalorimetrischen Daten von einer Sauerstoffbombe verglichen.