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THERMAL DECOMPOSITION OF SHAMPOOS

MAREK WESOŁOWSKI

Analytical Chemistry Department, Faculty of Pharmacy, Al. K. Marksa 107, Pl 80-416 Gdańsk (Poland)

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ABSTRACT

The thermal decomposition of 31 shampoos was investigated. The decomposition of these formulations has been found to proceed in three stages. In the temperature range from 303 K to 443–463 K, a mass loss of 72 to 93% occurred, which is connected with the release of liquid components of the shampoos. In the second and third stages, a mass loss of ca. 12% is observed, which is associated with the decomposition of the remaining components of the formulation. The residue after the decomposition of shampoos is a mixture of inorganic compounds.

INTRODUCTION

Shampoos are water–alcoholic solutions of several liquid and solid chemical compounds, mainly organic, which differ in their elemental composition, chemical constitution, molecular mass and physicochemical properties. The particular components of the formulations occur in extremely different amounts.

Wendlandt and Collins [1–3] were among the first to investigate the problem of thermal analysis of multicomponent mixtures, to which the pharmaceuticals belong. They found that it was possible to use DTA, DSC, and TG thermal decomposition curves for the identification of particular formulations, which provided the basis of the use of thermoanalytical methods in crime detection. In addition, the studies of Radecki and Wesołowski [4–6] indicated that it is possible to determine the characteristic thermal decomposition features of the active substance, which can then be utilised for the identification of the formulation. This makes also possible the determination of a pharmaceutical's content in some forms of drugs.

The encouraging results in the case of pharmaceuticals caused us to include more complex products, i.e. shampoos, into the thermal investigation. These formulations have, so far, not been studied in this way.

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EXPERIMENTAL

Materials

In this study 31 shampoos were used: Chmielowy, Jacek i Agatka, Kasztanowy, Miętowy, Perłowy F, Perłowy Z, Perłowy X, Piwny, Pokrzywowo-łopianowy, Shampoo and Ziołowo-emulsyjny (Cosmetic Works, Pollena-Uroda, Warszawa), Lecytynowy, Perlisty, Pokrzywowy, Rumiankowy, Tataro-chmielowy and Szałwiowy (Cosmetic Works, Pollena-Ewa, Łódź), Finezja (Cosmetic Works, Pollena-Miraculum, Kraków), Ada, Bambi, Brzozowy, Eurydyka, Familijny, Jajeczny, Super and Sylwia (Economic Chemistry Works, Pollena, Katowice), To-Ja (Economic Chemistry Works, Pollena, Gdańsk), Azulenowy (Chemical Co-operative, Postęp, Sopot), Diana (Chemical-Cosmetic Co-operative, Bytochemia, Bytom), Popularny (Chemical Works by J. Śniadecki, Toruń) and Zeńszeniowy (Chemical Works, Viola, Gliwice).

Testing technique

The thermal decomposition of shampoos and their components was carried out using the OD-103 derivatograph, model 3427 at 1500°C (MOM, Budapest, Hungary). All measurements were done under identical conditions. The 200-mg samples were heated in platinum crucibles of 9.5 mm diameter in a furnace atmosphere and under atmospheric pressure at a rate of temperature increase of 5° min^{-1} up to a final temperature of 973–1073 K. α-Al_2O_3 was used as the reference material. Each thermogram was recorded 3–6 times.

The residues, which were obtained as a result of evaporation of 10-g shampoo samples to constant weight on a water bath, were decomposed by heating a 100-mg sample.

RESULTS AND DISCUSSION

From the analysis of the shapes of the DTA, TG and DTG thermoanalytical curves of all the shampoos examined and from the data in Table 1 it follows that the decomposition of these products proceeds, in principle, in three stages. This is illustrated in Fig. 1, where the DTA, TG and DTG decomposition curves of the Ada shampoo (curve A) and of the To-Ja shampoo (curve C) are demonstrated. Over the temperature range from 303 K to 443–463 K, a rapid loss in mass is observed. The endothermic effect on the DTA curve indicates that this is associated with the release of liquid shampoo components, such as water, alcohol and glycerol. However, the DTA, TG and DTG curves provide no information which is useful for the unequivocal identification of any of the components released in this stage.

TABLE 1

Results of the thermal decomposition of shampoos

Trade name	Decomposition stages					
	I		II		III	
	Temp. (K)	Residue (%)	Temp. (K)	Residue (%)	Temp. (K)	Residue (%)
Ada	303–453	10.5	453–508	6.0	508–603	2.0
Azulenowy	303–443	15.0	443–483	12.0	483–738	3.0
Bambi	303–443	12.0	443–488	9.0	488–603	3.5
Brzozowy	303–433	23.0	443–503	14.5	503–713	3.0
Chmielowy	303–453	19.0	453–518	15.0	518–873	5.5
Diana	303–433	22.0	443–493	17.0	493–593	6.0
Eurydyka	303–463	20.0	463–523	12.5	523–728	3.5
Familijny	303–433	15.5	433–503	11.0	503–683	6.0
Finezja	303–438	18.0	438–543	7.0	543–693	2.5
Jacek i Agatka	303–443	14.5	443–538	9.0	538–853	2.0
Jajeczny	303–428	23.0	428–533	14.0	533–713	5.5
Kasztanowy	303–473	17.0	473–533	14.0	533–923	4.0
Lecytynowy	303–433	13.0	453–493	9.5	493–753	2.0
Miętowy	303–448	17.0	448–508	14.5	508–673	7.0
Perlisty	303–433	28.0	433–533	20.0	533–753	5.0
Perłowy F	303–448	19.5	448–493	16.0	493–703	3.0
Perłowy Z	303–438	18.5	458–513	13.5	513–683	6.0
Perłowy X	303–433	17.5	443–493	13.0	493–713	4.5
Piwny	303–428	15.5	443–498	10.5	498–683	3.0
Pokrzywowy	303–433	10.5	453–493	7.5	493–613	2.0
Pokrzywowo-łopianowy	303–443	16.0	443–513	10.0	513–623	3.0
Popularny	303–453	7.0	453–493	5.0	493–573	2.0
Rumiankowy	303–443	10.0	463–493	6.5	493–753	1.5
Shampoo	303–433	10.5			503–623	4.0
Super	303–453	10.5	453–543	2.0	543–653	0.5
Sylwia	303–433	14.5	433–493	11.5	493–693	6.5
Szałwiowy	303–453	9.5	468–513	5.5	513–593	1.0
Tataro-chmielowy	303–443	10.0	443–498	5.5	498–603	1.5
To-Ja	303–438	18.0	438–493	14.5	493–873	6.0
Żeńszeniowy	303–443	17.5	443–503	12.0	503–913	2.0
Ziołowo-emulsyjny	303–443	17.5	443–498	13.0	498–703	3.0

The residue, which constitutes 7–28% of the shampoo mass, undergoes decomposition in two stages. Depending on the chemical composition of the formulation under study a loss in mass prevails in the second and third stages, which is reflected by the shapes of the TG and DTG decomposition curves. The second stage ends within the temperature range 493–533 K and is accompanied by a mass loss of 4–6%. The Ada shampoo is an example of

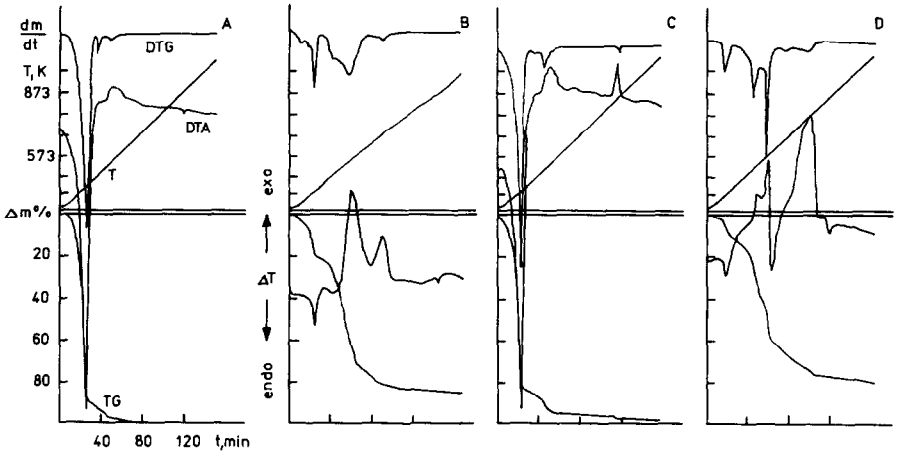

Fig. 1. DTA, TG and DTG curves of the thermal decomposition of the shampoos, (A) Ada and (C) To-Ja, and of the residues obtained as a result of evaporation of the shampoos on a water-bath, (B) Ada and (D) To-Ja.

a formulation which is characterized by a distinct loss in mass in the second stage. On the DTG curve a not too large, narrow effect is observed. For the To-Ja shampoo, only a slight deflection of the DTG curve from the level is observed over the same temperature range. A considerable effect mass loss, of about 10%, for the To-Ja shampoo is observed only in the third decomposition stage. For most shampoos this stage ends within the temperature range 593–623 K, with the formation of several per cent of residual. In certain cases the coked residue remaining after decomposition of the shampoo burns off slowly, so that the decomposition of the products ends ultimately within the temperature range 693–753 K. The inorganic compounds, which constitute the residue after thermal decomposition of shampoos, melt at higher temperatures. This process is confirmed by a slight endothermic effect seen on the DTA curve of the Ada shampoo at a temperature of about 883 K. The inorganic compounds can also undergo a thermal dissociation, interreact, or form eutectic mixtures. A high and narrow exothermic effect seen on the DTA curve of the To-Ja shampoo at a temperature of about 853 K may result from the chemical reaction between the components of the mixture after decomposition.

Since the DTA, TG and DTG thermal decomposition curves provide no information which makes possible the identification of the composition of shampoos, it was decided to carry out a thermal analysis of the residues, which were obtained as a result of evaporation of 10-g shampoo samples to constant weight on a water bath. The shapes of the thermal decomposition curves of the products, having the consistency of an ointment, are demonstrated in Fig. 1, parts B and D. The multitude of thermal effects indicates that this is a mixture of several or more compounds, both organic and

inorganic. Due to the lack of information from the manufacturers on the composition of the formulations it is not possible to identify any of the components of the shampoos examined without the aid of classical checking methods [7]. From this it follows that thermoanalytical methods will not find application in qualitative and quantitative control of shampoos.

CONCLUSIONS

From the investigation carried out it follows that the DTA, TG and DTG thermal decomposition curves of shampoos are the result of physicochemical and thermochemical phenomena which occur in the sample under the conditions of a linear increase of temperature. The thermal effects seen on the DTA curves are results of superimposing the endo- and exothermic effects due to the transitions of particular components. The mass losses seen on the TG curves are the total losses in mass of the decomposition processes which proceed over the temperature range examined. In this connection there exist very serious difficulties in the identification of the reaction which is responsible for the appearance of a definite effect on the thermoanalytical curves.

Summarizing the results of the investigation it can be stated that there are very serious difficulties in recognizing both the thermoanalytical decomposition processes of the components of the shampoos examined, and the nature of the intermediate decomposition products being formed; this eliminates the possibility of applying thermal analysis methods in qualitative and quantitative control of complex multicomponent mixtures, such as the shampoos. Only the total content of the liquid components of a shampoo and the temperature range of particular decomposition stages can be determined, which can be utilized for distinguishing the particular samples of shampoos from each other.

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