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THE APPLICABILITY OF DTA TO THE STUDY OF CERAMIC FIBRES

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ABSTRACT

To determination of thermal properties of different ceramic fibres the DTA method has been applied. Characteristic temperatures of the glass fibres have been determined. As a result of the study of aluminosilicate fibres temperature of mullite crystallisation has been evaluated. Alumina spinel polycrystalline fibres were obtained from organic solutions and then they were heated to get ceramic structure. DTA and TG methods can be applied to the investigation of chemical processes during decomposition of organic component and forming of fibres ceramic structure.

INTRODUCTION

Ceramic fibres are of growing interest and importance for a variety of applications such as high temperature insulation, hot gas filtration, the reinforcement of metals, etc. Their application and work temperature depend on chemical composition and fibres structure. In particular, fibres shape i.e. lenght to diameter high ratio and a diameter about 1-5 μm makes them peculiary sensitive for processes occured at higher temperatures. From this reason DTA methods can be recommended as a kind of quick control of fibres properties. Obviously, the kind of physical variables to be measured depends on fibres species, which will be discussed below.

GLASS FIBRES

DTA of glass fibres, powdered to the lenght below 0.01 mm is similar to the DTA of glass powder with the same chemical composition. In this way one can determine characteristic temperature in such the glass which physical and chemical properties undergoe quick changes [1, 2]. From a point of view of fibres properties the transformation temperature Tg is most significant. This temperature determines fibres thermal resistance and limits the fibress applications at higher temperatures. The specific heat of glass increases at this temperature and causes endothermic effect. The initial part of this peak can be connected with Tg temperature, when

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one can observe the collapse of the whole structure under gravitional force as the fibres soften. Softening and weakening of fibres cause extensive fracture of fibres and the destruction of many of the interconnected insulating cells, which eliminates them as thermoinsulating material.

One can obtain another glass characteristic temperatures from DTA curve, but they are less significant for fibres properties and applications. DTA curve of glass fibres is shown in Fig. 1.

ALUMINOSILICATE FIBRES

Aluminosilicate ceramic fibres consist of glass as well but the latter has different physical character because it crystallises above 900 °C. The product of the crystallisation is mullite. Application temperature of these fibres is considerably higher than Tg temperature. It is possible to determine mullite crystallisation temperature from DTA curve. Detailed study of mullite crystallisation allows to find out its peculiarity [3]. The results of this study carried into the new kind of aluminosilicate fibres with glass-ceramic structure as an effect of mullite controlled crystallisation [4]. Temperatures of mullite crystallisation are determined from DTA curve - glass Tg as nucleation temperature and the maximum temperature of mullite crystals growth. The application temperature of glass-ceramic fibres is about 200 - 300 °C higher and chemical resistance is few times better than values for common fibres.

$MgO.Al_2O_3$ SPINEL FIBRES

One of new kind of ceramic fibres is alumina polycrystalline fibres which are obtained from alumina salt aqueous solution [5]. These fibres are drawn out from viscous solution and then they are dried on the warm air and they solidify as "green fibres". Green fibres consist of solid alumina organic polymer.

The method of $MgO.Al_2O_3$ spinel fibres production was worked out in Institute of Material Science and Engineering. These fibres are obtained from acetate-formate aqueous solution. Green fibres of 75 weight % of organic part which decomposes and it is burned out during fibres heating. The formation of fibres ceramic structure is not easy, it can lead to fibres destruction into small pieces.

DTA and DTG methods are usable to study of this process. DTA and DTG of $MgO.Al_2O_3$ spinel fibres are shown in Fig. 1. One can observe many different reactions connected with weight loss and heat emission. But only two of them seems to be important for fibres stability. First of them has a maximum yield at about 300 °C and it is connected with the start of CO_2 evolution. Tartaric acid polymer decomposition takes place at this temperature and fibres destroy if temperature growth is to fast. The burning out and CO_2 evolution give high exothermic peak at higher temperatures but these processes do not lead to fibres failure.

The another destroying reaction is process taking place at about 500 °C. It is connected with CH_4 evolution but the nature of this reaction is not known. It is necessary to apply another methods e.g. infra-red of Raman spectroscopy to explain the kind of this process.

SUMMARY

DTA and another connected methods as DTG, TG and chromatographic gases analysis are useful to the study of different ceramic fibres. These characteristical points can be determined directly from DTA curve for glass fibres or DTA date can be used for nature recognition of mullite crystallisation in aluminosilicate fibres. In other case DTA method must be completed by additional investigations as for example infra-red spectroscopy applicable to study of alumina acetate-formate fibres decomposition.

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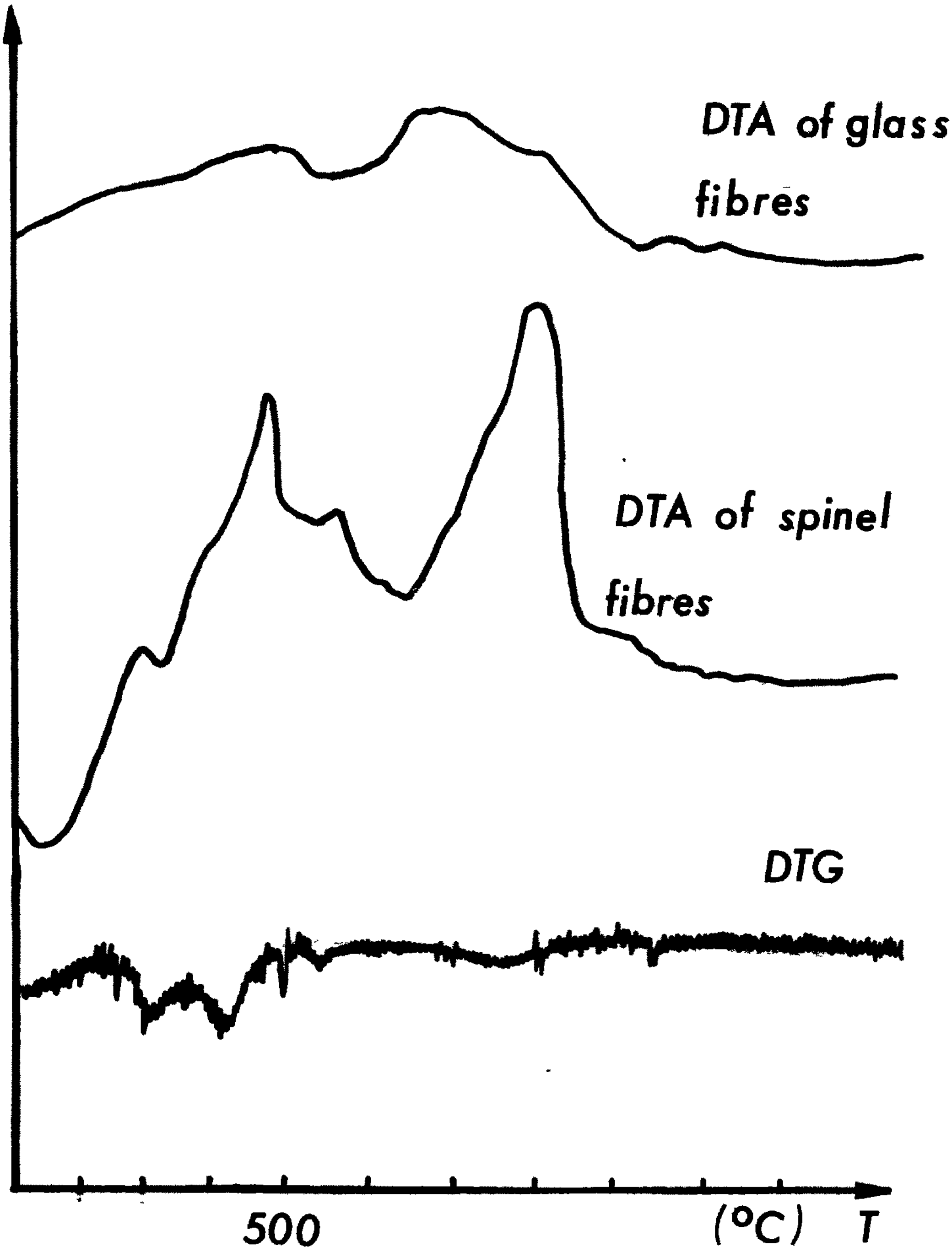

Fig.1 DTA, DTG of ceramic fibres.