

# OPTIMISATION OF THE CERAMIC PHASE FOR CERAMIZABLE SILICONE RUBBER BASED COMPOSITES

Zbigniew Pędzich<sup>1, a</sup>, Jan Dul<sup>2</sup>

<sup>1</sup> AGH University of Science & Technology, Dept. of Advanced Ceramics,  
Mickiewicza 30, 30-059 Kraków, Poland

<sup>2</sup> Institute for Polymers & Dyes Technology, Division of Elastomers & Rubber Technology,  
Harcerska 30, 05-820 Piastów, Poland

<sup>a</sup>pedzich@agh.edu.pl

**Keywords:** silicone based composites, ceramization.

**Abstract.** Paper describes the experiment on manufacturing of composite basing on silicone rubber matrix filled with silica binder and kaolin and also glassy fillers. Such material is oriented on applications connected with potential fire hazard. Investigations performed on three mixes, differentiated in proportion of components, indicate potential simply way of composition of ceramizable composite.

## Introduction

Flame resistance of electrical cable covering insulation is very important from the safety point of view of people using means of transport, visiting shopping centers, sport halls, theatres or cinemas. Metal rods in protective covering make the main part of electrical circuits, responsible for distribution of electricity in cars and planes, providing power supply for elevators or fire-fighting systems. Material used nowadays, based on silicone rubber or PVC is incombustible, but the problem concerns its mechanical durability under flame, maintaining circuit integrity and energy supply during fire, indispensable to secure time for evacuation or emergency landing. Integrity of electrical cables can be obtained by application of covering insulation made of polymer composites ceramizing at high temperature arising during fire [1]. The paper presents results of investigation on optimization of ceramic phase using in one type of mentioned composites basing on kaolin additive into silicone matrix.

## Experimental

Materials used for investigation were silicone-basing composites. They were composed of silicon rubber containing silanized Silbond binder, kaolin and glassy phase in different proportions. Details were collected in the Table 1.

Table 1. Components proportion of investigated materials.

Component	phr (parts per hundred of rubber)		
	Sample A	Sample B	Sample C
Silicon rubber	100	100	100
Silbond	14,3	17,5	21
Kaolin	28,5	14	18
Glass	2	17,5	8

Sample A was relatively rich in kaolin additive and poor in glassy phase introduced into the composite. Sample B has similar amounts of kaolin and glass on moderate level. Sample C was rich in silica and kaolin; glass amount was established on the moderate level.

Composites were fired using controlled temperature of 1050°C. Microstructure of ceramized samples was examined by scanning electron microscopy equipped with energy dispersion spectroscopy detector (Nova Nano SEM 200 firmy FEI & Oxford Instruments). Samples were also examined by DSC/TG (Differential Scanning Calorimetry/Thermogravimetry) up to 1050°C (Netzsch STA449F3 Jupiter).

## Results

Figures 1 – 3 present DSC/TG measurements. All samples showed similar mass loss (~40%) caused by elastomer degradation. Heat effects detected up to 600°C could be derived from elastomer firing. Literature described such process in details, e.g. [2]. Usually, the maximum exothermic peak correlated with the final polymer decomposition appears ~550-600°C [3]. For investigated composites, it appeared ~520°C. It is probably the effect of overlapping of the exothermic effect connected with polymer decomposition and endothermic effect caused by kaolin transformation (535°C, see Fig. 4). Such coincidence attenuates intensity of the heat effect caused by polymer firing. The exothermic effect described to mullitization (over 990°C) is extinguished by low kaolin content.

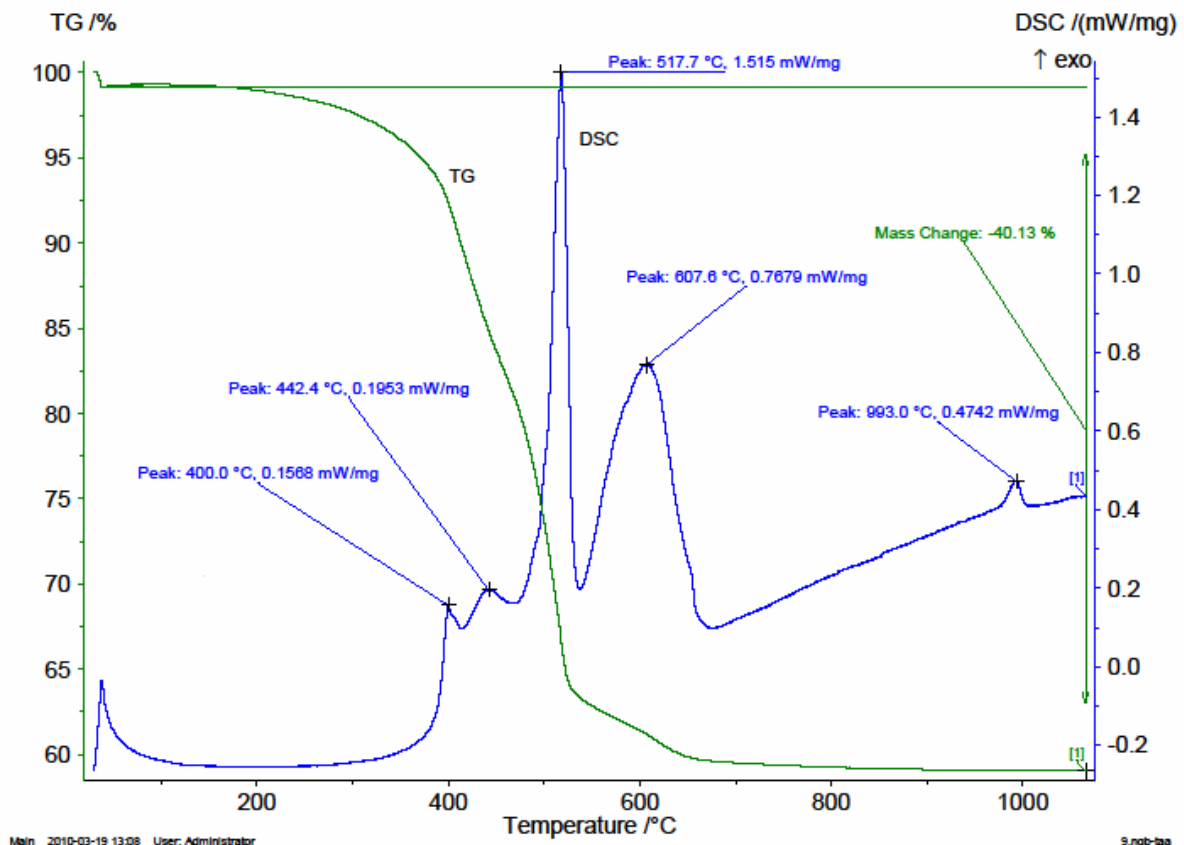


Fig. 1. Results of DSC/TG measurements of Sample A.

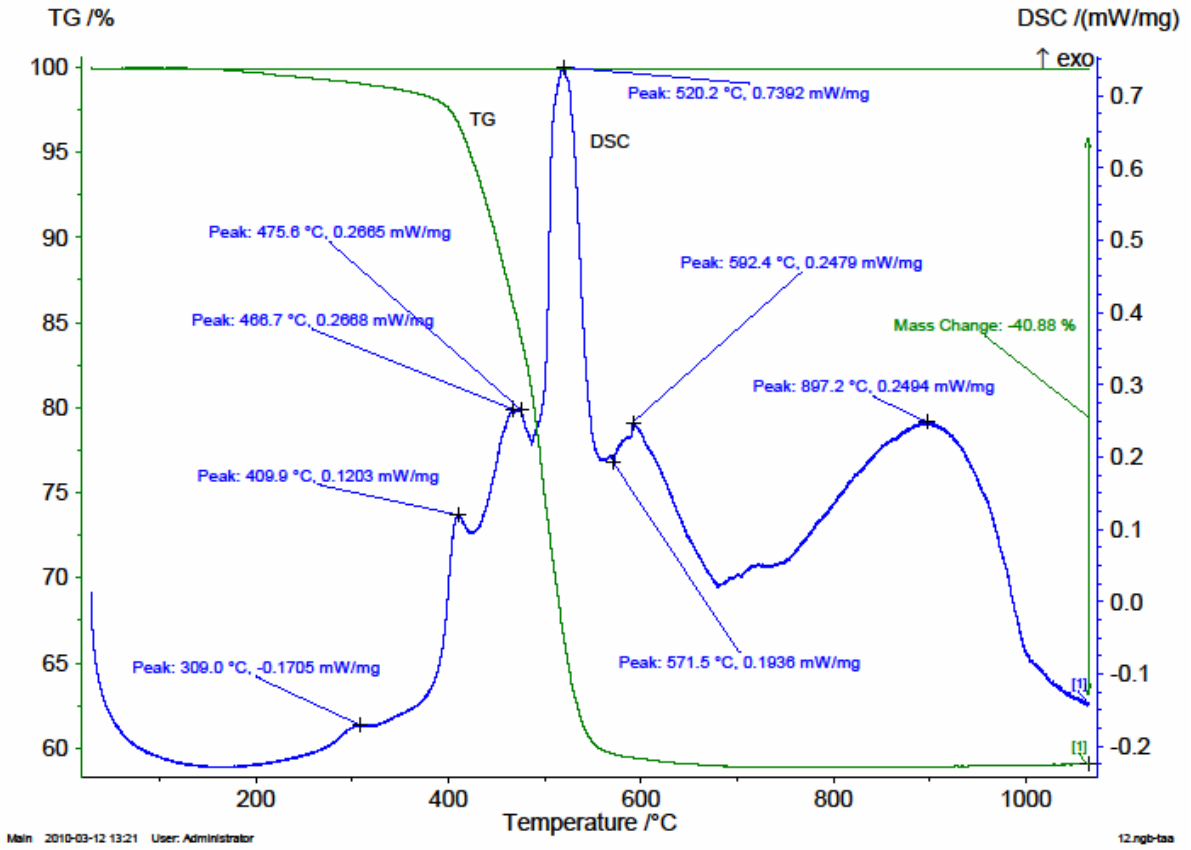


Fig. 2. Results of DSC/TG measurements of Sample B.

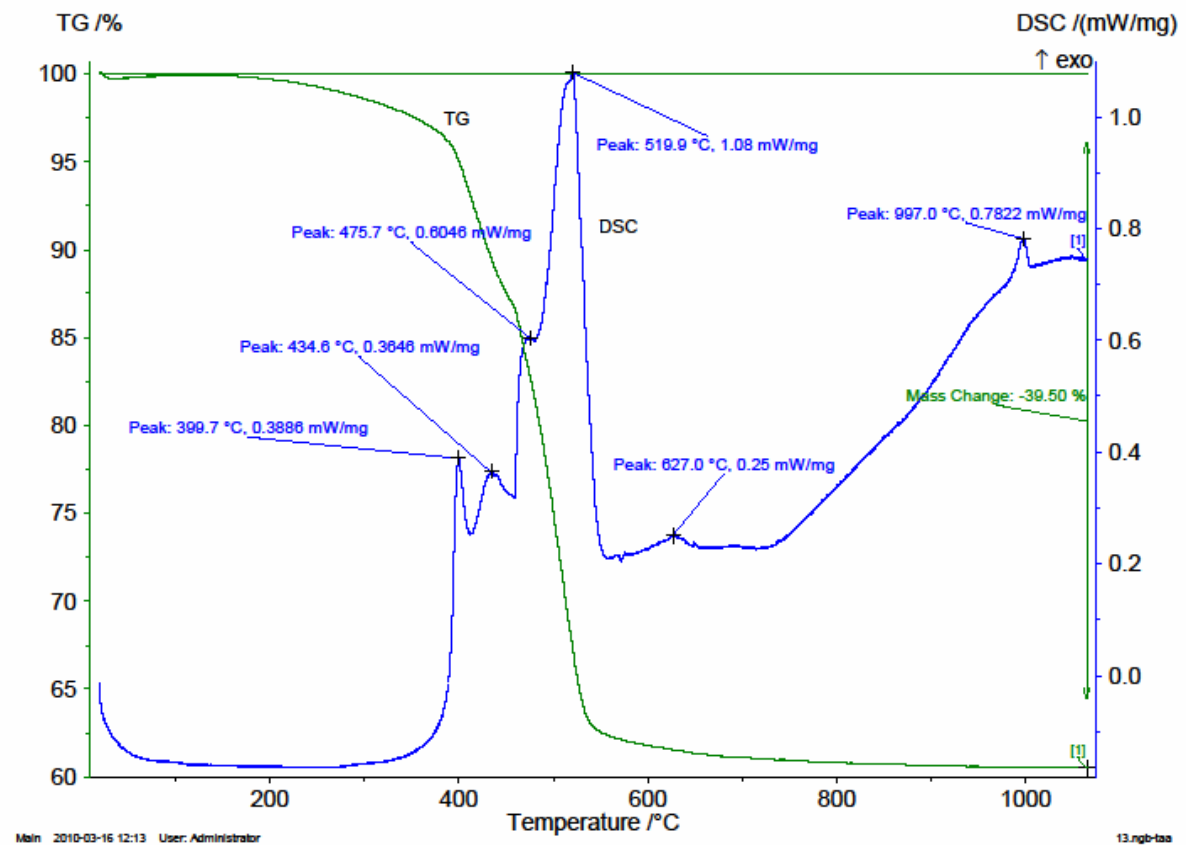


Fig. 3. Results of DSC/TG measurements of Sample C.

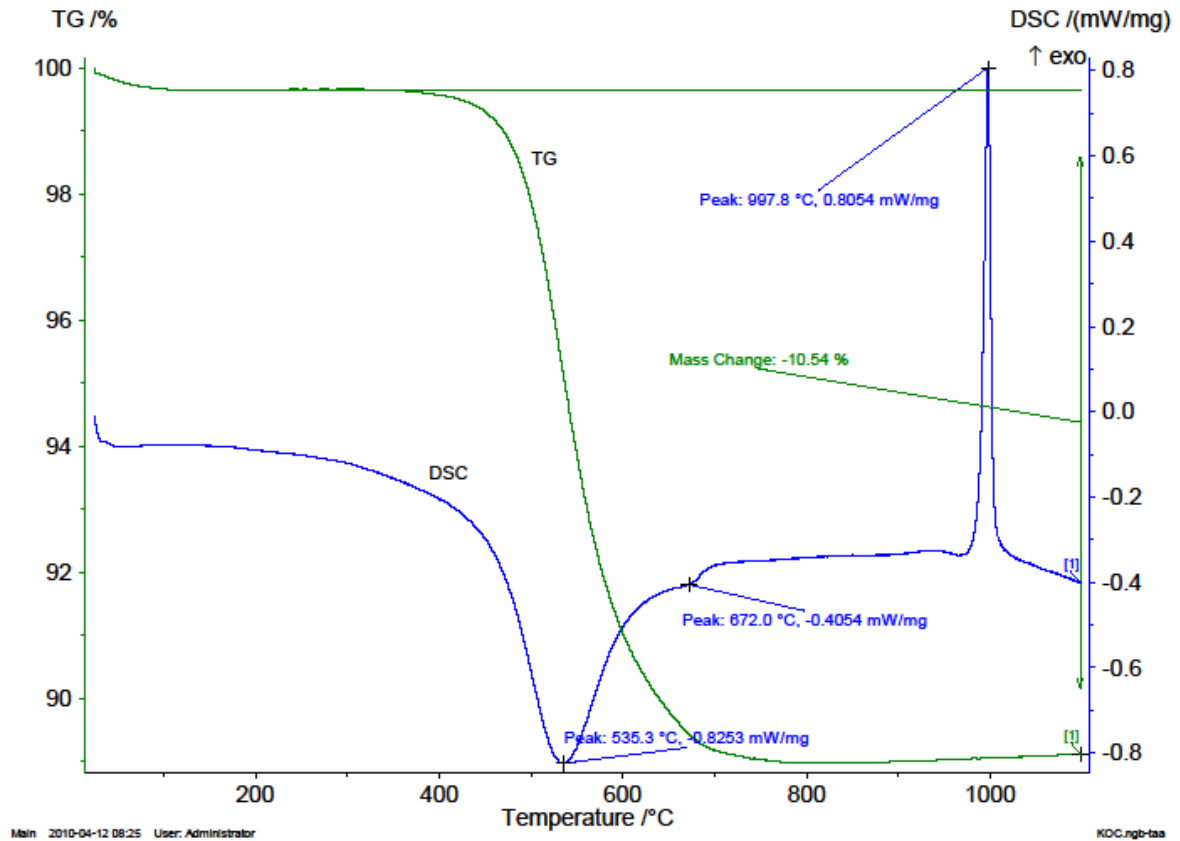


Fig. 4. Results of DSC/TG measurements of kaolin component.

Photographs at Figure 5 represents samples after ceramization in 1050°C. White dust visible on the surface of all samples is a fumed silica produced during ceramization, not binded into ceramic body created in this process. Sample A, with low glass content is not compact, its surface covered with separate layers. Sample B is distinctly compact but during ceramization its shows large shrinkage. Sample C showed the most promising morphology among investigated items.



Fig. 5. Samples after ceramization in 1050°C (Samples A, B, C - from left to right hand side).

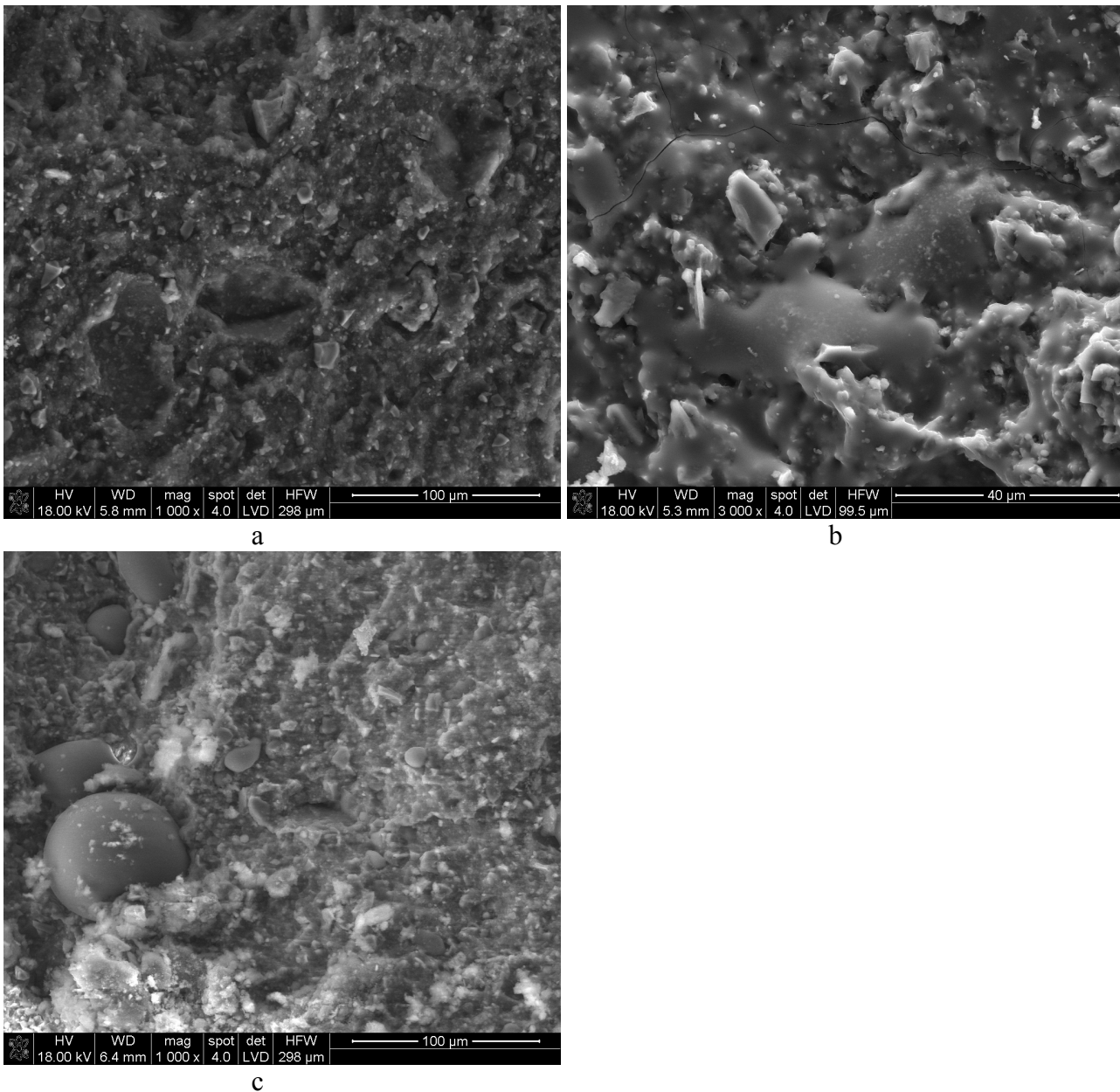


Fig. 6. SEM micrographs of ceramized composite microstructures: a – sample A, b – sample B and c – sample C.

Images of ceramized composites microstructures collected in Figure 6 illustrate the main differences between investigated samples – the lack of glassy phase in Sample A, the excess of glass in Sample B and troubles with glassy phase homogenization in the composite caused by not enough wettability of glass and other components.

## Summary

Performed experiment confirms the manufacturing possibility of ceramizable composites basing on silica rubber containing glass and kaolin admixtures. The temperature range of kaolin decomposition corresponds to temperature range of the final phase of silica rubber degradation and temperature of glass melting. It creates favorable conditions for creation of ceramized body, when proportion of constituent components is proper.

Performed tests showed that the product of ceramization of investigated samples could be compact enough. Its potential application demands the additional technological test focused on thermal properties and rheological properties of composite mix during processing.

## Acknowledgements

Authors are greatly indebted to Mrs. B. Trybalska from Faculty of Materials Science and Ceramics of AGH - University of Science and Technology (Krakow, Poland) for microscopic observations assistance.

We would also like to express our thanks to Dr. M. Szumera and Dr G. Grabowski from Faculty of Advanced Ceramics of AGH for their thermogravimetical analyses.

The work was financially supported by the European Union within a framework of National Coherence Strategy under Innovative Economy Operating Programme; grant no. POIG.01.03.01-00-067/08-00.

## References

- [1] Processable silicone composite materials having high temperature resistance. *US Patent* 5552466 (03.08.1996)
- [2] S. Hamdani, C. Longuet, D. Perrin, J.-M. Lopez-cuesta, F. Ganachaud, Flame retardancy of silicone-based materials, *Polymer Degradation and Stability* 94 (2009) 465–495
- [3] K. Hayashida, S. Tsuge, H. Othani, Flame retardant mechanism of polydimethylsiloxane material containing compound studied by analytical pyrolysis techniques and alkaline hydrolysis gas chromatography, *Polymer* 44 (2003) 5611-561