BOOK OF ABSTRACTS

The 3rd International Conference on Nanomaterials: Fundamentals and Applications

October 09-11, 2017, Štrbské Pleso, High Tatras, Hotel Patria, Slovak republic

Organized by:

Department of Physical Chemistry
Faculty of Natural Sciences
Pavol Jozef Safarik University in Kosice
&
Slovak Chemical Society
Bratislava

 ISBN: 978-80-8152-530-8

Edited by: **Andrea Straková Fedorková**, Pavol Jozef Šafárik University in Košice, Institute of Chemistry, Moyzesova 11, 040 01 Košice, Slovakia, andrea.fedorkova@upjs.sk

Ondrej Petruš, Pavol Jozef Šafárik University in Košice, Institute of Chemistry, Moyzesova 11, 040 01 Košice, Slovakia, ondrej.petrus@student.upjs.sk

Reviewed by: **Renáta Oriňáková**, Pavol Jozef Šafárik University in Košice, Institute of Chemistry, Moyzesova 11, 040 01 Košice, Slovakia, renata.orinakova@upjs.sk

Andrej Oriňák, Pavol Jozef Šafárik University in Košice, Institute of Chemistry, Moyzesova 11, 040 01 Košice, Slovakia, andrej.orinak@upjs.sk

 ISBN: 978-80-8152-530-8

LIST OF CONTENTS

 ISBN: 978-80-8152-530-8

Nanoceramic composites based on organomagnesiumoxanealumoxanes

T. Apukhtina[a]*, G. Shcherbakovaa, M. Varfolomeev[b], A. Rumina[a], N. Krivtsova[a], A. Drachev[a]

[a] *State Research Institute for Chemistry and Technology of Organoelement Compounds, Moscow, Russia* [b] *Moscow aviation institute (National research university), Moscow, Russia*

**tatiana.apukhtina@yandex.ru*

Nanostructured ceramics have unique properties and performance characteristics. However, monolithic nanoceramics are inferior to nanoceramic composite materials, reinforced by continuous or discontinuous ceramic fibers, according to some physical-mechanical parameters, for example, in crack resistance (fracture toughness). The use of discontinuous fibers for reinforcing ceramics has a number of significant advantages, such as precise control of the fiber amount, fabrication cost reduction, and simpler production of irragular shapes. However, a disadvantage of composites reinforced with discontinuous fibers is that they have lower fracture toughness, as compared to composites reinforced with continuous fibers. To improve this parameter, the most uniform mixing of the chopped fibers with the matrix is required.

Another possible method to avoids the problem of homogeneous dispersion of fibers within the matrix is self-reinforcement of the composite [1].

We obtained nanoceramic composites (Fig. 1) from powders of nano-SiC, micro-SiC and a binder based on organomagnesiumoxanealumoxanes [2] (precursors of aluminum-magnesium spinel) first synthesized in the State Research Institute for Chemistry and Technology of Organoelement Compounds, and reinforcing discontinuous spinel fibers of $MgAl_2O_4$ composition. Spinel fibers were obtained by forming polymer fibers from fiber-forming organomagnesiumoxanealumoxanes [2, 3], followed by their pyrolysis (Fig. 2). It is known that due to the high melting point (2135 ºC), hardness, chemical resistance and strength, which remain at high temperatures, aluminum-magnesium spinel is an effective material for high-temperature technology.

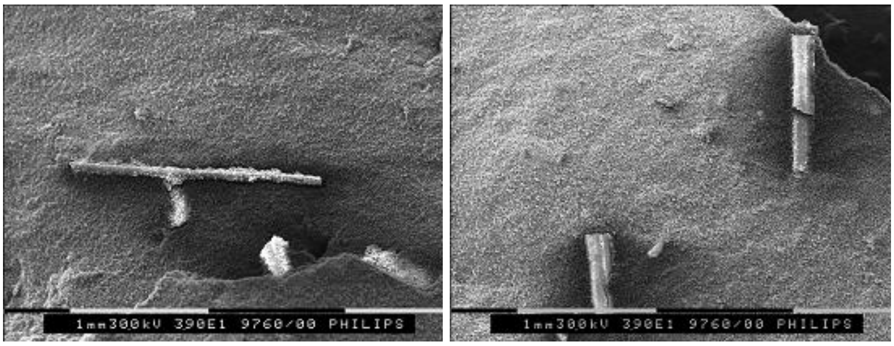
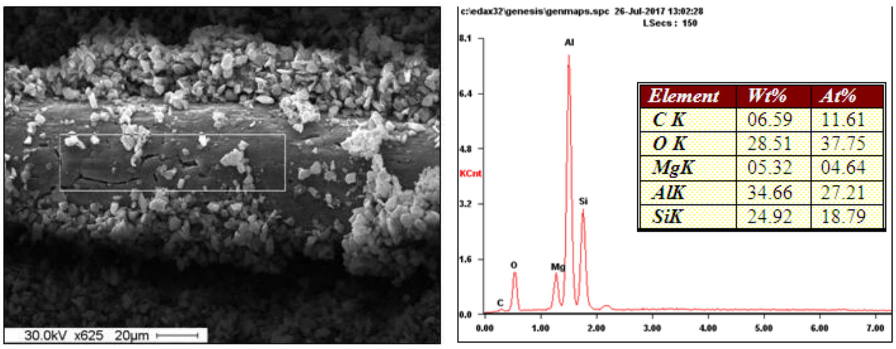


Fig.1 – SEM of the nanoceramic composite



Element	Wt%	At%
C K	06.59	11.61
O K	28.51	37.75
MgK	05.32	04.64
AlK	34.66	27.21
SiK	24.92	18.79

Fig. 2 – SEM and X-ray elemental microanalysis of spinel fiber in a ceramic composite

 ISBN: 978-80-8152-530-8

Moreover, the formation of nanofibers composed of Si_3N_4 was observed. That is, self-reinforcement of the nanoceramic composite occurred (Fig. 3), which positively effected its physical and mechanical properties (density, strength, fracture toughness).

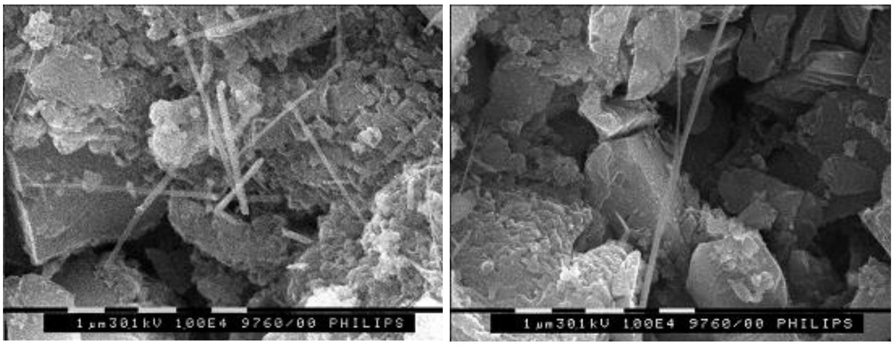


Fig. 2 – SEM of self-reinforced nanoceramic composite

Thus, organomagnesiumoxanealumoxanes can be effectively used as precursors of components (binders, fibers, powders) for high-strength and high-temperature nanoceramic composites.

Acknowledgements

This work was supported by the Russian Foundation for Basic Research, project no. 17-03-00331 A.

References

[1] K. Itatani, S. Yoshiyama, H. Suemasu, et. al. 16th International Conference on Composite Materials.
[2] G.I. Shcherbakova, N.S. Krivtsova, T.L. Apukhtina, et. al. RF Patent 2615147 C1, 2017.
[3] G.I. Shcherbakova, P.A. Storozhenko, T.L. Apukhtina, et. al. Polyhedron **135** (2017) 144–152.

 ISBN: 978-80-8152-530-8

SESSION IV Advanced preparation methods and characterization techniques of nanomaterials

Nano-oxide ceramics based on organoelementoxanes

G. Scherbakova[a*], T. Apukhtina[a], P. Storozhenko[a], M. Varfolomeev[b], A. Ashmarin[c]

[a] *State Research Institute for Chemistry and Technology of Organoelement Compounds, 105118 Moscow, Russia*
[b] *Moscow aviation institute (National research university), 125993 Moscow, Russia*
[c] *Baikov Institute of Metallurgy and Material Science RAS, 119334 Moscow, Russia*

**galina7479@mail.ru*

The ceramic-forming organoelement poly(oligo)mers are a new class of promising precursors for obtaining high-temperature and oxidation-resistant components (ceramic fibers, matrixes, combined protective and barrier coatings, powders) of nanostructured ceramic composites. They allow to apply radically different "polymer technology" for ceramics production through pyrolysis of the ceramic-forming organoelement poly(oligo)mers [1].

On the basis of unstable chemically active organoaluminum compounds we have developed a method for the synthesis of hydrolytically stable in air ceramic-forming organoalumoxane oligomers - chelated alkoxyalumoxanes [2].

It is found that the thermochemical treatment of ceramic-forming organoalumoxanes results in corrundum ceramics α-Al_2O_3 [2].

Based on such ceramic-forming organoalumoxanes, a process for the preparation of a high-purity nanostructured, silica free organoalumoxane binder of corundum composition α-$A1_2O_3$ was developed [3].

The ceramic-forming organoalumoxanes were found to readily interact with metal alkoxides and acetylacetonates and they may comprise a wide range of elements and metals in various combinations and ratios with homogeneous distribution in oligomer matrix on a molecular level. This provides a perfect nanostructure, enhanced physical-mechanical and operational properties of ceramic composites obtained on the basis of ceramic-forming organoelementoxanes. The organometallic synthesis ensures high purity of the starting oligomers. This allows obtaining high-purity oxides of elements of a given composition and producing materials on their base at much lower temperatures as compared with technical-grade oxides use [1].

The hydrolytically stable in air, soluble in organic solvents ceramic-forming organoyttriumoxanealumoxanes having fiber-forming properties were synthesized by the co-condensation of chelated organoalumoxane oligomers and yttrium acetylacetonate [4,5].

Thermochemical transformation (pyrolysis) of ceramic-forming organoyttriumoxanealumoxanes at 1500 °C results in aluminum-yttrium ceramics.

It is found that the pyrolysis of organoyttriumoxanealumoxanes with Al:Y≈1.5-1.7 leads to the formation of an aluminum-yttrium garnet, the samples are a ceramic matrix consisting of globular formations with nanostructured elements whose characteristic dimensions do not exceed 10 nm.

Polymeric organoaluminum-yttrium fibers based on organoyttriumoxanealumoxanes in the pyrolysis process are transformed into ceramic refractory oxide fibers based on alumina, modified with yttrium oxides, including fibers of aluminum-yttrium garnet $Al_5Y_3O_{12}$ composition [5].

The hydrolytically stable in air, soluble in organic solvents ceramic-forming organomagnesiumoxanealumoxanes having fiber-forming properties were synthesized by the chelated alkoxyalumoxane interaction with magnesium acetylacetonate [6].

We found that organomagnesiumoxanealumoxanes pyrolysis with molar ratio of Al:Mg = 2:1 even at 900 ºC results in magnesium-aluminate $MgAl_2O_4$.

Based on ceramic-forming organoelementoxanes (organoalumoxanes, organoyttriumoxanealumoxanes, organomagnesiumoxanealumoxanes) the researchers of SSC RF GNIIChTEOS developed effective method for obtaining components of heat - resistant ceramics and ceramic composites of oxide composition (Al_2O_3, Y_2O_3–Al_2O_3, MgO–Al_2O_3): binders, impregnation compositions, ceramic nanopowders [1,3,6,7].

Acknowledgements

This work was supported by the Russian Foundation for Basic Research, project no. 17-03-00331 A.

References

[1] G.I. Shcherbakova, P.A. Storozhenko, M.S. Varfolomeev et al. *Nanotechnics*. 3(35) (2013) 15-23.

[2] P.A. Storozhenko, G.I. Shcherbakova, A.M. Tsirlin, et. al. *Inorganic Materials*. **43** (2007) 320-382.

 ISBN: 978-80-8152-530-8

[3] M.S. Varfolomeev, V.S. Moiseev, G.I. Shcherbakova, et. al. *Inorganic Materials*. **51** (2015) 76-81.
[4] G.I. Shcherbakova, P.A. Storozhenko, N.B. Kutinova, et. al. *Inorganic Materials*. **48** (2012) 1058-1063.
[5] G.I. Shcherbakova, T.L. Apukhtina, P.A. Storozhenko, *Inorganic Materials*. **51** (2015) 206-214.
[6] G.I. Shcherbakova, N.S. Krivtsova, T.L. Apukhtina, et. al. RF Patent 2615147 C1, 2017.
[7] M.S. Varfolomeev, V.S. Moiseev, G.I. Shcherbakova, et. al. *Inorganic Materials*. **51** (2015) 722-727.

 ISBN: 978-80-8152-530-8