PhD STUDIES COURSE UNIT DESCRIPTION

Name of subject	Field of science, code	Faculty / Center	Department
Sol-gel chemistry of transition metal oxides	Chemistry N 003	Faculty of Chemistry and Geosciences, Institute of chemistry	Department of Inorganic Chemistry
Student's workload	**Credits**	**Student's workload**	**Credits**
Lectures		Consultations	
Independent study	10	Seminars	

Course annotation
Basic concepts of dispersion systems. Classification. General regularities of sol formation. Physical and chemical methods. Sol purification. Durability and coagulation of sols. Rheological and optical properties of sols. Introduction to the chemistry of sol-gel processing. Sol-gel synthesis method. Synthesis of transition metal oxides. Sole-gel process in aqueous medium. Hydrolysis and condensation reactions in the aqueous solutions of inorganic salts of transition metals. Hydrolysis of metal cations. Load - pH diagrams. Initiation of condensation reactions. Olation mechanism. Formation of deposits and gels. M (II) metal oxide sols and gels. M (III) metal oxide sols and gels. Oxidation mechanism. Polyanions. Role of the anion on the hydrolysis and condensation reactions in the aqueous solutions of inorganic salts of transition metals. Indirect study of the sol-gel process of transition metals. Solution chemistry of transition metal alkoxide precursors. Hydrolysis and condensation of metal alkoxides. Chemical modification of metal alkoxides. Metal carboxylates. Metal alkoxides with polidentated ligands. Ligand exchange reactions. Hydrolysis and condensation reactions in solutions of inorganic salts and alkoxides of aluminum. Aggregation and intercalation. Anisotropic aggregates. Intercalation properties of vanadium pentoxide gels. Physical properties of transition metal oxide gels. Synthesis of multicomponent metal oxides by sol-gel method. High temperature superconductors. Ferroelectric materials. Silica gels. Aluminates. Synthesis of alloyed alumina and aluminates. Method for the synthesis of carboxylate alumoxanes. Synthesis and application of perovskite materials. Optical materials. Bioceramic materials. Formation of thin and thick films by sol-gel method.
Reading list
1.C. J. Brinker and G. W. Scherer. Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing. Academic Press, London, 1990. 2.J. Livage, M. Henry and C. Sanchez. Sol-Gel Chemistry of Transition Metal Oxides. Progress in Solid State Chemistry. 18 (1988) 259-342. 3.A. Kareiva. Aqueous sol-gel synthesis methods for the preparation of garnet crystal structure compounds. *Materials Science (Medžiagotyra),* **17** (2011) 428-437. 4.K. Ishikawa and A. Kareiva. Sol-gel synthesis of calcium phosphate-based coatings – a review. *Chemija*, **31** (2020) 25-41. 5.K. Ishikawa, E. Garskaite and A. Kareiva. Sol-gel synthesis of calcium phosphate-based biomaterials - A review of environmentally benign, simple and effective synthesis routes. *J. Sol-Gel Sci. Technol*., **94** (2020) 551-572.

The names of consulting teachers	Science degree	Main scientific works published in a scientific field in last 5 year period
Aivaras Kareiva	Habil. Dr.	1. L. Sinusaite, A. Popov, E. Raudonyte-Svirbutaviciene, J. C. Yang, A. Kareiva and A. Zarkov. Effect of Mn doping on hydrolysis of low-temperature synthesized metastable alpha-tricalcium phosphate. *Ceramics Int*. **47** (2021) 12078-12083. 2. A. Laurikenas, D. Sakalauskas, A. Marsalka, R. Raudonis, A. Antuzevics, V. Balevicius, A. Zarkov, A. Kareiva. Investigation of lanthanum substitution effects in yttrium aluminium garnet: Importance of solid state NMR and EPR methods. *J. Sol-Gel. Sci. Technol.,* **97** (2021) 479-487. 3. L. Sinusaite, A. Kareiva and A. Zarkov. Thermally induced crystallization and phase

		evolution of amorphous calcium phosphate substituted with divalent cations having different size. *Crystal Growth & Design.* **21** (2021) 1242-1248. 4. D. Karoblis, A. Zarkov, E. Garskaite, K. Mazeika, D. Baltrunas, G. Niaura, A. Beganskiene, A. Kareiva. Study of gadolinium substitution effects in hexagonal yttrium manganite $YMnO_3$. *Scientific Reports*. **11** (2021) 2875. 5. A. Čiuladienė and A. Kareiva. Application of red paint data library for the characterization of the manuscript from Grand Duchy of Lithuania. *Microchem. J.,* **164** (2021) 105961. 6. R. Diliautas, A. Beganskiene, D. Karoblis, K. Mazeika, D. Baltrunas, A. Zarkov, R. Raudonis and A. Kareiva. Reinspection of formation of $BiFe_{1-x}Mn_xO_3$ solid solutions via low temperature sol-gel synthesis route *Solid State Sci.,* **111** (2021) 106458.

Certified during Doctoral Committee session on September 28th, 2021. Protocol No. 610000-KT-142.
Committee Chairman prof. habil. dr. Aivaras Kareiva