


**16<sup>th</sup> INTERNATIONAL MULTIDISCIPLINARY  
SCIENTIFIC GEOCONFERENCE  
SGEM 2016**

Book 6  
**Nano, Bio and Green -  
Technologies for a Sustainable Future**  
CONFERENCE PROCEEDINGS  
Volume I



MICRO & NANO TECHNOLOGIES  
ADVANCES IN BIOTECHNOLOGY

- 9. CORROSION LOSSES OF ALLOY 06XN28MDT IN CHLORIDE-CONTAINING COMMERCIAL WATERS**, Prof. DrSc Alexei Narivskiy, Prof., DrSc Gulmira Yar-Mukhamedova, Prof., DrSc Elmira Temirgaliyeva, PhD Munira Mukhtarova, Yerlan Yar-Mukhamedov, al-Faraby Kazakh National University, Kazakhstan.....63
- 10. CORROSION RESISTANCE OF CHROME-SILOX-CARBON NANOCOMPOSITION ELECTROLYTIC COATINGS**, Prof. DrSc Gulmira Yar-Mukhamedova, Prof. DrSc Kanat Mukashev, Prof. Abyl Muradov, Prof. Raushan Shiderova, al-Faraby Kazakh National University, Kazakhstan .....71
- 11. DEPOSITION OF Ni-P-Al<sub>2</sub>O<sub>3</sub> COMPOSITE LAYER ON THIN STEEL STRIP**, Prof. Tamara Radu, Assoc. Prof. Lucica Balint, Lecturer Dr. Gina Genoveva Istrate, Lecturer Dr. Alina Mihaela Cantaragiu, Dunarea de Jos University of Galati, Romania.....79
- 12. DEVELOPMENT AND CHARACTERIZATION OF ERYTHROMYCIN AND AVOCADO OIL-BASED ANTI-ACNE MICROEMULSIONS**, Assoc. Prof. Dr. Lacramioara Ochiuz, Dr. Manuela Hortolomei, Assoc. Prof. Dr. Alina Stefanache, Prof. Dr. M. Popa, Prof. Dr. Gladiola Tantar, Gr. T. Popa University of Medicine and Pharmacy, Romania.....87
- 13. DEVELOPMENT OF LIPID NANOPARTICLES COMPRITOL® BASED AS CARRIERS FOR AMIODARONE**, Assist. Dr. Andreea Creteanu, Assoc. Prof. PhD Alina Stefanache, Dr. Anca Grigoras, Dr. Alina Diaconu, Assoc. Prof. Dr. Lacramioara Ochiuz, Gr. T. Popa University of Medicine and Pharmacy, Romania .....95
- 14. EVALUATION OF THERMAL PROPERTIES OF CARBOXY-PHENOXYCYCLOTRIPOSPHAZENES**, PhD Student Darya V. Panfilova, Assoc. Prof. PhD Evgeniy M. Chistyakov, Assoc. Prof. PhD Sergey N. Filatov, PhD Student Anton S. Typikov, PhD Michael I. Buzin, D. Mendeleyev University of Chemical Technology of Russia, Russia .....103
- 15. EVALUATION VIA NANOINDENTATION OF IMPROVED TECHNOLOGICAL PROCEDURE FOR MANUFACTURING POLYMER PACKAGINGS FOR PHARMACEUTICAL AND COSMETIC INDUSTRY**, Assoc. Prof. Dr.Margarita Natova, Ivan Ivanov, Prof. Dr.Rumen Iankov, Assoc.Prof. Dr. Maria Dacheva, Assist. Prof. Dr. Sabina Cherneva, Institute of Mechanics of Bulgarian Academy of Sciences, Bulgaria .....111
- 16. FABRICATION OF ULTRAFINE GRAINED COMPOSITES BY MECHANICAL ALLOYING AND DYNAMIC CONSOLIDATION OF POWDERS**, Nikoloz Chikhradze, Guram Abashidze, Mikheil Chikhradze, Akaki Gigineishvili, Giorgi Mestvirishvili, G. Tsulukidze Mining Institute, Georgia .....119

## CORROSION RESISTANCE OF CHROME-SILOX-CARBON NANO-COMPOSITION ELECTROLYTIC COATINGS

Prof., DrSc Gulmira Yar-Mukhamedova<sup>1</sup>

Prof. DrScKanat Mukashev<sup>1</sup>

Prof. Abyl Muradov<sup>1</sup>

Prof. Raushan Shiderova<sup>2</sup>

<sup>1</sup> Al-Farabi Kazakh National University, IETP, **Kazakhstan**

<sup>2</sup> Almaty University of Power Engineering & Telecommunications, **Kazakhstan**

### ABSTRACT

The report presents the results of experiments on introduction of nano-size particles of silicon dioxide SiO<sub>2</sub> (5-50 nm) and lamp soot C (11-100 nm) into chromium electrolytic coating and investigation of corrosion resistance in 3% NaCl solution. Nano-composition electrolytic coatings were obtained at the various density of current: 2, 3, 4, 5, 6, 7 kA/m<sup>2</sup>, temperature 303-343 K and nano-dispersion phase components' ratio. The morphology of coatings surface was investigated by electron- and atom-force microscope before and after corrosion tests. It was established, that nanostructured composition electrolytic coatings, which were obtained in electrolytes containing 18-14 g/dm<sup>3</sup> SiO<sub>2</sub> and 2-6 g/dm<sup>3</sup> C, temperature 303-343 K, density of current - 4-5 kA/m<sup>2</sup>, have the highest corrosion resistance.

**Keywords:** nanostructured composition electrolytic coatings (nano-CEC), corrosion resistance, pitting, microstructure.

### INTRODUCTION

The metals corrosion protecting problem is an actual not only in Kazakhstan, but all over the world [1-6]. Composite electrolytic coatings (CEC) showed oneself to advantage both for protection against corrosion and for increase of wear resistance, and also for the sizerenewal. Nano-particles of various compositions are more actively used as a disperse phase in recent years. It is known, that replacement of fundamental resistance of traditional materials by using nano-dispersion powders opens large perspectives for creation of new materials and technologies [7-10]. So using nano-size powders in electroplating sphere gives possibility both for improving main parameters and for creation of composites with specific properties.

The research progress and development levels increase necessity making new materials. Composite electrolytic coatings plays main role in decisions of this problem. Composite electrolytic coatings - that in which consists matrixes of the metal and in which there is dispersion phase. If dispersion particles is will less 100

nm, then they fall into row is nano materials and particles dispersion definitively to change characteristic of the matrix of the metal. So notion composite electrolytic pillowcase adjusts in separate group, but main nanocomposite electrolytic pillowcase and main exploratory work elaborates their characteristic and structures. The characteristic CM not always requires full volume concentration and objects, only in determined stage to becloud it is enough. The method nanocomposite electrolytic pillowcase (nano-CEP) give possibility together mix dispersion particles and metal-electrolytic [11-15].

The galvanic method has such doubtless advantages as: possibility of making CEC with demanded structure and properties; absence of thermal influence on a part and a coating; possibility of exception of the subsequent machining; the low net cost. In view of the aforesaid it is necessary to investigate chromium - silicon dioxide - lamp soot nano-CEC's physical and chemical special properties.

The aim of the work is research corrosion resistance of chromium - silicon dioxide - lamp soot nano-CEC for determining an optimum ratio of components and regimes for effective protecting coatings electro deposition.

## EXPERIMENTS

For testing of corrosion resistance of chromium - silicon dioxide - lamp soot nano-CEC the experimental device for corrosion resistance determining by a weight method adjusted for coatings working conditions was developed, assembled and completed (Fig. 1). The testing stand consists of peristaltic pump 1, boiler 2 for keeping constant temperature, distributor of water stream 3, communicating columns 4 for positioning tested samples; thermometer for corrosive medium 5 and buffer 6 temperatures control. In parallel columns the holders of samples are placed, due to this holders 8 coupons, placed for 4 samples per each shoulder of the stand, are simultaneously tested in identical conditions. The speed of stream done by the peristaltic pump is 40 vol/min. 3 % solution of sodium chloride was chosen as the corrosion medium because chlorine ions are high antagonists of chromium. Temperature of the corrosion medium was 293 K.

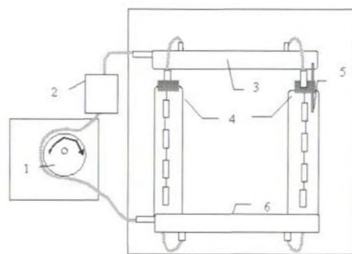


Fig. 1. Corrosion testing equipment

Due to the fact chrome has most hardness, durability and anticorrosive stability in many hostile environments, they were chosen as matrix metal of CEC. Chrome can quickly passivated with formation of a strong and reliable film, and so chrome has become the basic and integral component of all sorts of rustproof and heat-resistant steels. Before testing samples were preliminary degreased, washed out by the distilled water until completely wetting. Then samples were dried up, packed into a filtering paper, kept in exiccator with dehumidifier within 1 hour and weighed on analytical scales accurate within 0,0001 g. Results are processed in accordance with GOST 9.506-87, p. 2.6, accuracy indicator – E is defined in accordance with GOST 9.502-82.

Well-known, that during composite coatings precipitation the disperse phase entered into electrolyte not always gets to a coating and is overgrown with electrodeposited metal. To confirm incorporation into a chromic matrix of silicon dioxide nano-particles entered into electrolyte we have carried out researches on an atom-force microscope (AFM) "ItegraTerma".

## RESULTS AND DISCUSSIONS

Whereas nano-CEC were put onto steel St.3, efficiency of nano-CEC anticorrosive stability was estimated in comparison with corrosion stability of steel St.3 without coating. Therefore corrosion tests of samples from St.3 without coating were preliminary conducted by gravimetric method (table 1).

Table 1. Results of steel St.3 corrosion resistance investigations

t, h	$m_0, 10^{-3} \text{kg}$	$m_1, 10^{-3} \text{kg}$	$\Delta m, 10^{-3} \text{kg}$	$K, 10^{-3} \text{kg} / \text{m}^2 \text{h}$
5	17,2019	17,2041	0,0022	0,1989
10	17,2041	17,2058	0,0017	0,2672
15	17,2058	17,2048	0,0011	0,2455
20	17,2048	17,2019	0,0029	0,37395

The table's data show, that within 10 hours there is an intensive dissolution of steel, then the passivation film is formed and covers surface of the sample with a friable inhomogeneous layer, which is destroyed for the following 5 hours and carried away by a stream of corrosive medium. Then deeper layers of steel are further dissolved, continuously changing film of corrosion products is emerged.

The same method was used for estimation of corrosion stability of nano-CEC, obtained from electrolytes with concentration ratio of lamp soot and silicon dioxide (g/l): 2/18, 4/16, 6/14, 8/12, 10/10, 12/8, 14/6, 16/4 and 18/2. In spite of a variety of sedimentation modes and nano-dispersion phases concentrations ratio in electrolyte, all coatings showed 15-36 time increase of corrosion resistance in comparison with St. 3 and 5-12 time increase in comparison with pure chromic electrolytic coating. The deep

parameter of corrosion thus was  $0,005-0,02 \cdot 10^{-3}$  depending on modes of sedimentation and electrolyte composition.

We carried out research of corrosion resistance at specially developed stand on the basis of Wheatstone bridge use. In figure 2 change of corrosion resistance depending on time is presented, the figure shows, that the highest resistance has nano-CEC, obtained at 333 K ( $28 \cdot 10^{-3}$  Ohm), and lowest at 303 K ( $12 \cdot 10^{-3}$  Ohm). To find out the cause of corrosion stability increase, we had been studied nano-CEC microstructure by methods of raster electronic and atom-force microscopy.

AFM allows to receive the unique information about a surface structure, to define deformation-strength and relaxation properties on micro- and nano-dimensioned level. AFM research of the sample can carry out due to the forces arising between cantilever and nano-CEC surface. Various forces prevail depending on distance between the surface and a sonde. We carried out researches by a contactless method at cantilever-sample distances about several tens angstrom, where the main interaction is the intermolecular one named Van der Waals forces. The atom-force microscopy gives the opportunity for realization of the new approach in research of the surface, and allows to expand possibility for getting the many-sided information on morphology and surface characteristics of nano-CEC with the high spatial permission.

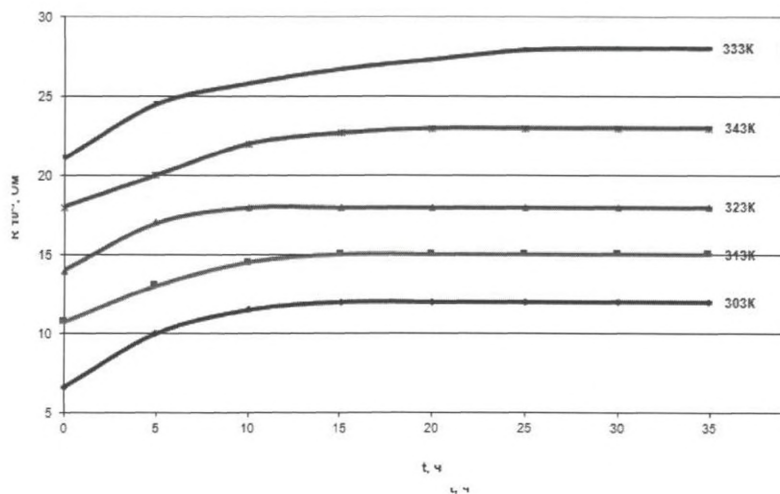


Fig. 2. Dependence of electroresistance on duration of corrosion tests for nano-CEC, obtained from electrolyte with concentration 2 g/l C+18 g/l SiO<sub>2</sub>

In figures 3 and 4 atom-force microscopy pictures are presented, which show that nano-CEC, obtained at temperature 303 K has large-globular structure. Obviously more smooth structure of surface of Cr-SiO<sub>2</sub>-C nano-CEC, obtained at temperature 333 K is the cause of high corrosion stability of these coatings.

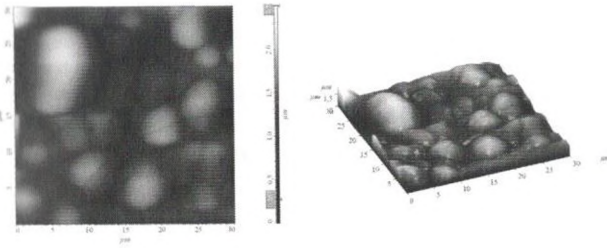


Fig. 3. AFM image of nano-CEC Cr-SiO<sub>2</sub>-C, obtained at temperature 303 K

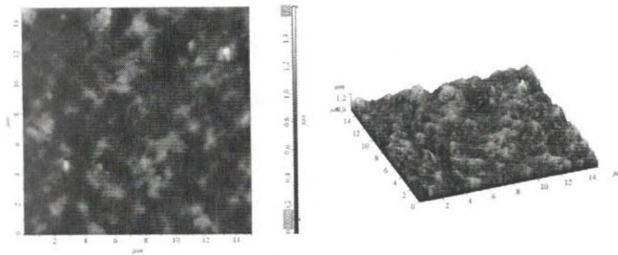


Fig. 4. AFM image of nano-CEC Cr-SiO<sub>2</sub>-C, obtained at temperature 333 K

## CONCLUSIONS

The results of carried out investigation are the following.

The experimental devices for corrosion resistance test by a weight method and a method of electric resistance measuring were developed, assembled and completed;

The technique for investigation of corrosion resistance of Cr-SiO<sub>2</sub>-C nano-composition electrolytic coatings in 3 % NaCl solution was worked out by two methods. The microstructure of chromium - silicon dioxide - lamp soot nano-CEC before and after corrosion was studied by methods of an optical metallography, raster electronic and atom-force microscopy;

Influences of nano-CEC composition and regimes of their obtaining: current density; electroplating speed; microhardness, - on corrosion resistance of Cr-SiO<sub>2</sub>-C coatings were investigated. It is established that nano-CEC 18 g/l SiO<sub>2</sub>-2 g/l C, 16 g/l SiO<sub>2</sub>-4 g/l C, 14 g/l SiO<sub>2</sub>-6 g/l C, obtained at current density 4 A/dm<sup>2</sup> and temperature 333K have the highest corrosion resistance.

#### ACKNOWLEDGMENTS

We acknowledge with a deep sense of gratitude, the encouragement and inspiration received from our colleagues, working on project 3110/GF4 "Development of cost-effective technology for production of nanostructured composite coatings chromium-whitesoot with improved anticorrosion properties" (Institute of Experimental and Theoretical Physics).

#### REFERENCES

- [1] Bush H. E., Donham James E., Alkire John D., Ibarra S., Stastny T. M., Place M.C. Problems encountered and protective measures. Metals Handbook. Vol. 13. Metals Park (Ohio). 1989, p. 1245-1259.
- [2] Broutman L.J., Krok R.H. Composite Materials. New-York-London: Academic press, V.1-5, 2008.
- [3] Swidzinski M.A. Offshore protection: painting for a 20-year// J. Prot. Coat. and Linings, 2007, Vol. 14, N5, P. 46-53.
- [4] Jackson K. Recent advances in water-borne protective coatings// Surface Coat. Int. 1999, Vol. 82, N7, P. 340-343.
- [5] Brown E.E. Effect of flow rates on localized corrosion behaviors of 304 stainless steel in ozonated 0.5 N NaCl // Corrosion. 1992, V.48, №12, P. 970-975.
- [6] Wyllie W.E. The effects of dissolved ozone on the corrosion behavior of stainless steels in artificial seawater // Corrosion. New Orleans, 436, 33, P.107, 2007.
- [7] Yar-Mukhamedova G. Sh. Modified electrolytic Cr-based composite coatings / Materials Science, Ukraine, Vol. 35, issue 4, pp.601-602, 1999.
- [8] Brown B.E. The effects of dissolved ozone on the corrosion behavior of nickel, stainless steels, and aluminum-based alloys in artificial seawater // Tri-service conference on corrosion, Wrightsville, P.135-150, 2007.
- [9] Martin T.A. Cobalt-chromic oxide composite coating for high-temperature wear resistance// Plating and Surface Finish, 2004, Vol. 71. N9, P.51-53.
- [10] Yar-Mukhamedova G., Darisheva A., Kasimzhanov K. Physicochemical Investigations of Scheelite Concentrate Decomposition // Eurasian Chemical-Technological Journal, № 17, p. 209-212, 2015.
- [11] Pokhmursky V. I., Khoma M. S. The role of electrochemical factors in the initial stage of fatigue-corrosion destruction of stainless steels / Protection of Metals, Russia, Vol. 43, N 3, pp. 247-254, 2007.
- [12] Farrokhzad, M. A.; Saha, G. C.; Khan, T. I. Three-body wear performance of co-electrodeposited cermet coatings / Wear, USA, Vol. 313/ issue 2, pp. 34-42, 2014.



- [13] Sakhnenko M.D., Ovcharenko O.O., Ved' M.V., Lyabuk S.I. Physicomechanical Properties of Cu -Al<sub>2</sub>O<sub>3</sub> Electroplating Compositions // Materials Science, 2015, Vol. 50, Issue 5, pp. 646-652.
- [14] Bykanova V.V., Sakhnenko N.D., Ved' M.V. Synthesis and photocatalytic activity of coatings based on the Ti<sub>x</sub>Zn<sub>y</sub>O<sub>z</sub> system // Surface Engineering and Applied Electrochemistry, Vol.51, № 3, pp. 276-282, 2015.
- [15] Yar-Mukhamedova G.Sh. Investigation of the Texture of Composite Electrodeposited Chromium-Carbon Coatings. Materials Science. September 2000, Volume 36, Issue 5, pp 752-754.