ABSTRACT

For the thesis "Preparation of anti-corrosion coatings based on polymers and cotton tars for the main oil pipelines" by Sakibaev Berik Abdrazakhovich, submitted for the degree of Doctor of Philosophy (PhD) in specialty 6D072100 – "Chemical technology of organic substances»

Importance of the research. Large volumes of metal consumption and harsh operating conditions of oil and gas field equipment make the problem in increasing the durability of equipment operation as one of the central problems that determine the growth rates and technical and economic efficiency of oil and gas production, transportation and refining. The main losses from corrosion are due to premature failure of metal structures, where the cost of their production is significantly higher than the cost of the used metal. The second largest item of expenditure is a set of measures to combat corrosion. A large place among the various options in corrosion protection coatings for oil pipelines and equipment has insulation by polymeric materials. But the production of most of them is based on imported materials. The problem of efficient processing of secondary resources to obtain competitive products is relevant for all industrialized countries. The necessity for this thesis is due to modern requirements to solve the problem of finding affordable materials to obtain effective and cheap composite materials to create coatings and protect oilfield equipment from corrosion in aggressive highly mineralized environments, as well as the decision of the Government of the Republic of Kazakhstan to establish a cotton cluster in the South of Kazakhstan. In relation to this there will be a need for new resource-saving technologies for the disposal of cotton oil waste and obtaining environmentally friendly and economical products based on cotton oil waste.

In this research the problems of obtaining new materials for anti-corrosive protection of oilfield equipment and waste disposal are solved comprehensively through the use of waste oil and fat production from cotton tars, as well as various mineral fillers and other local materials in order to produce modern materials.

In recent decades, the objective in developing new materials is solved by modifying the base brands of existing large-capacity polymers, because modification of known polymers, the creation of polymer composite materials is one of the main and economically justified areas of development in modern technology and equipment for many industries. Composite materials, including those with electret properties and nanocomposites, have a number of significant advantages, often they are able to improve the modulus of elasticity, strength, thermal and chemical stability, resistance to combustion, reduce the gas permeability of the material, etc. Modern economic environment are shaping the need in the production of materials with sufficient accessibility and cheapness. Achieving the optimal ratio between the cost and effective characteristics of the polymer composite material could be received through the use of affordable and inexpensive fillers, as well as various waste products, the

use of which can reduce not only the cost of production, but also to eliminate their negative impact on the environment.

The purpose and objectives of the research. The purpose of the work is to obtain anticorrosion coatings based on polymers and cotton tars for the main oil pipelines.

To achieve the aim the following tasks were set:

- carry out analysis of the problems in protection of oilfield equipment in aggressive highly mineralized environments;
- review prospective protective coatings for oilfield equipment;
- select the objects of study;
- provide the material base of research;
- carry out analytical and experimental studies of actual problems of polymer modification in order to regulate their properties;
- justify the ways to achieve the optimal ratio between cost and effective characteristics in the modification of polymers;
- carry out semi-industrial tests of new compositions of composites.

Scientific novelty of the study. The scientific novelty of the research consists in using the ability of technical gossypol-(2,2-di-3-methyl-5-isopropyl-1,6,7-trioxy-8-naphthaldehyde) – a yellow pigment of cotton oil (both in free form and in the composition of cotton tar) - to show the properties of an active inhibitor of radical reactions, an oxidation inhibitor of polyolefins, a polymer stabilizer, and the possibility of establishing an optimal ratio between the cost and characteristics of polymer composites through the use of affordable and inexpensive fillers and various waste products, the use of which will provide innovative import-substituting products. As a result of the implementation of this concept, the following results are obtained:

- the principal possibility in creation of production technologies of various anticorrosive coatings for protection of oilfield equipment from corrosion with use of waste of the oil and fat industry is proved and theoretically validated;
-identified feasibility of cotton tars to create a variety of polymer based composites systems: polymer – filler - compatibilizer – gossypol resin taking into account the relationship between parameters of structure, type of filler and the nature of the compatibilizer. The influence of the type of fillers on the physical and chemical properties of the obtained composites is shown, the combined effect of gossypol resin and various additives to improve the physical and mechanical properties of composites is revealed;
- theoretically and experimentally proved the possibility of providing high performance composites of complex composition due to the combination of effects of chemical and physical modification, including the use of gossypol resin;
- it was found that wollastonite and organically modified layered silicates (OLS) in composites are effective nucleates of crystallization and at the same time have a reinforcing effect, contributing to the formation of an adhesive bond between the polymer matrix and the filler, and also exhibit a synergistic effect with other

components, the result of these effects is a decrease in segmental mobility of macromolecules, which complicates the transition of macromolecules under the load from one conformation to another;

- the regularities of changes in viscoelastic, thermal, thermomechanical and deformation-strength properties of some modified composites were determined; the set of modification effects showed the polyfunctionality of the additives used and allowed to establish recommendations for the development of the formulation of complex composites with improved technological and operational properties.

Practical significance. The practical significance of the thesis is due to the large potential market for new products, including oil, gas, oil and gas processing, chemical and energy industries, and stricter requirements for the quality of protective coatings of pipelines and equipment. Development of technologies for producing modern multifunctional coatings using local materials and waste products for anti-corrosion protection of oil and gas pipelines and petrochemical equipment, taking into account the operating conditions, is of great practical importance for Kazakhstan.

Objects of research. The main objects of research were cotton tars, technical gossypol, low density polyethylene, vegetable and mineral fillers, compatibilizers.

Methods of research. The experimental base of research of this thesis includes physical, physicochemical, and chemical methods of research, designed to assess the properties of raw materials, products and their intermediates. Methods used are such as dispersion analysis, mechanical testing, rheological testing, tests of notched specimens, optical and electronic microscopy, etc. The combination of these methods allowed us to obtain complementary information about the studied objects. Thus, the reliability of the results obtained is ensured by the use of modern methods of analysis, mathematical processing of the results and laboratory tests.

Subject of research. Verification of the influence of aggressive highly mineralized environments on the durability of coatings.

Connection of the research with the plan of the scientific programs. The thesis was carried out in accordance with the themes of the state budget research B-11-03-05 in "South Kazakhstan State University of M. Auezov" and the Department of “Oil Refining and Petrochemistry" and "Petroleum Engineering" "Development and improvement of methods in intensification of oil and gas production, design and calculation of oil and gas equipment" and the agreement №199, program and target financing "Development of technologies for obtaining new effective materials for the oil and gas industry from waste oil and fat industry".

Basic findings for the defence:

- developed anticorrosion coating-lubricant "Gossi-SM", which provides optimal anticorrosion protection of metals in the open air by forming a self-tightening coating for the operation in different equipment such as protection of the external surfaces and other metal structures and equipment, including in highly corrosive environments.

- developed lubricating grease composition "Gossi-SK", which has a low cost and can be the basis of most non-antifriction greases, such as conservational, roping and threading greases;

- developed a method for producing bitumen-polymer mastic for an insulating anti-corrosion coating of a pipeline;

- developed composition for cold galvanizing "Goss-HC", which contains gossypol resin, modifying additives such as boric acid, boron nitride hexagonal modification, dicyandiamide, trichloropropyl phosphate and highly dispersed zinc powder.

- developed the "Gossi - NBRSE" composition on the basis of low-density polyethylene, butadiene − nitrile synthetic rubber stamp NBRS-18AMH, a copolymer of ethylene with vinyl and technical gossypol.

- results of industrial tests and calculation of the economic efficiency of the obtained anti-corrosion coatings.

Approbation of the thesis. The results of the research and the main findings of the thesis were presented at the international and national scientific conferences: “Innovative development of modern science: problems and prospects, Astana, 2017; International Scientific and Practical Conference “Actual scientific research 2018”, Moscow, 2018; Materialy XIV Miedzynarodowejnaukowi-praktycznejkonferencji, "Perspektywiczne opracowania są nauką i technikami - 2018", Prague, 2018.

Publications. The key points, results and conclusions of the thesis were presented in 18 publications, including one article in the International Scientific Journal indexed by Thomson Reuters; 10 articles in journals recommended by the Committee on the Control of Education and Science MES RK; 5 articles in materials of international conferences near and far abroad; 1 Eurasian patent; 1 monograph.

The structure and volume of the thesis. The thesis is presented in 128 pages of computer text, includes 25 tables and 22 figures. This thesis consists of an introduction, 3 chapters, conclusion, list of references and appendices.