Nanotechnology Application for Spacecraft Coatings: Pigment and Binder Modification

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Existing and used thermal control coatings (TCC), belonging to "optical solar reflector" type, are not the best in terms of both initial optical properties and operational characteristics, and stability during orbital flights. The main operational characteristic of TCC is integral absorption coefficient of solar radiation (a_s) which cannot be attributed to the most optimal.

The multiplication a_s by TCC area defines the value of absorbed flow of solar electromagnetic radiation and spacecraft temperature. With a_s increasing for maintaining the same temperature, the TCC area should be increased that leads to an increase in the weight and cost of space vehicle. The solution of problem is possible by means of using the compounds with large value of band gap as a pigment of TCC in order to avoid an absorption of the main part of solar spectrum quanta. The insulators with large band gap are attributed to such compounds.

Engineers, knowing the values of absorption coefficient a_s degradation of utilized TCC at certain orbit for period of flight, design such enlarged areas of the thermal control radiators that will ensure the maintenance of the required temperature throughout the flight of spacecraft. The usage of additional areas of TCC leads to space vehicle weight and cost increasing.

One of the perspective methods of TCC stability increasing during orbit flight is TCC pigment and binder modification by nanoparticles. Primary defects, formed in TCC due to ionization processes during an impact of solar quanta, electrons, and protons, are electron-hole pairs. Nanoparticles, precipitated on the pigment grains and introduced in grain volume and in a binder, work as relaxation centers of such pairs. It leads to a lower concentration of photo- and radiation defects and stability increasing of optical properties of TCC.

Efficiency of TCC pigment and binder modification by nanopowders is determined by many factors, the main of whose are: charge state and ionic radius of nanoparticle cation, ratio of ionic radii of nanoparticle cations and pigment, size and specific area of nanoparticles, physicochemical state of pigment surface, temperature and time of modification.

The known by now results of investigations in this direction show that the increase in the stability of TCC pigments due to modification reaches several tens of percent, while an increase in the stability of polymeric and inorganic binders can reach several hundred of percent.

In addition to TCC, this method can be used to improve the stability during orbital flights of other types of structural materials of space vehicles, especially polymeric materials.

The project is headed on a creation of high-stability TCC working in conditions of real orbits by modifying their pigments and binders by nanoparticles.