SYNTHESIS OF INORGANIC PIGMENTS BASED ON VANADIUM COMPOUNDS

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At present, SHS processes in exothermic organic systems (both powder and liquid) are very promising [1]. Yellow mineral pigments were obtained by the method of low-temperature combustion reactions (LTCR) using bismuth, zinc, and calcium vanadates.

The pigments were synthesized using V_2O_5 oxide, basic salt $BiONO_3 \cdot H_2O$, $Zn(NO_3)_2 \cdot 6H_2O$, $Ca(OH)_2$, and marshalite as the substrate. The starting components were mixed and citric acid was added. The solution was adjusted to pH = 2 with concentrated ammonia NH_4OH and boiled, followed by evaporation and calcination at a temperature of 500 °C. During synthesis, the following reactions occurred:

$$V_2O_5+2(NH_3 \cdot H_2O)=2NH_4VO_3+H_2O \quad (1)$$

$$2NH_4VO_3+BiONO_3=BiVO_4+NH_4NO_3 \quad (2)$$

$$C_6H_8O_7+3NH_4OH=(NH_4)_3C_6H_5O_7+3H_2O \quad (3)$$

$$4NH_4NO_3 \rightarrow 4NH_3\uparrow+4NO_2\uparrow+2H_2O+O_2\uparrow \quad (4)$$

$$(NH_4)_3C_6H_5O_7 \rightarrow 3NH_3\uparrow+4H_2O+CO\uparrow+CO_2\uparrow+4C \quad (5)$$

$$(HOOCCH)_2C(OH)COOH+O_2 \rightarrow 4C+4H_2O+CO\uparrow+CO_2\uparrow \quad (6)$$

$$C+O_2=CO_2 \quad (7)$$

At elevated temperatures, citric acid interacting with hydroxides forms oxalic and acetic acids, which decompose with the formation of carbon oxides and water. In an aqueous solution, citric acid can form chelate complexes with ions of metals that also decompose at high temperatures.

Figure 1 shows the X-ray diffraction patterns of the substrate mineral (marshallite), bismuth vanadate, and yellow pigment deposited on marshalite.

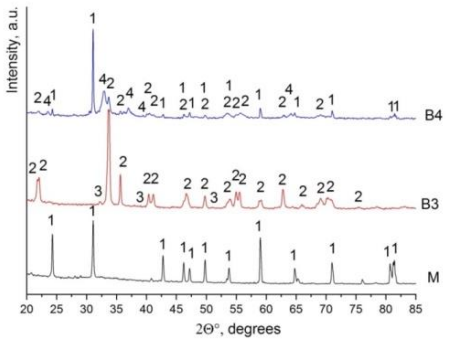

Fig. 1. X-ray diffraction patterns of marshallite and yellow pigment, where M is marshalite, B3 is bismuth vanadate $BiVO_4$, B4 is pigment deposited on marshalite, and used materials are: marshalite (1), $BiVO_4$ (Monoclinic 14-688) (2), VO_2 (Monoclinic 33-1441) (3), 4-$Bi_4V_2O_{11}$ (tetragonal 96-153-3809) (4).

As can be seen, bismuth vanadate contains VO_2 oxide as a microimpurity. 5-valence vanadium oxide subjected to thermal degradation of citric acid and ammonia can be reduced to a four-valence state. In addition to bismuth vanadate $BiVO_4$ and silicon oxide SiO_2, the yellow pigment deposited on marshalite contains complex $Bi_4V_2O_{11}$ oxide belonging to the family of bismuth-containing perovskites with the Aurivillius type of the structure and represented by the general formula $(Bi_2O_2)(A_{m-1}B_mO_{3m+1})$. The color of $Bi_4(V_2O_{11})$ compound is reddish-brown. Its small impurity in the pigment gives the yellow pigment a characteristic beige tone. The addition of Zn^{2+} and Ca^{2+} cations, which are contained in the starting components of the pigment ($Zn(NO_3)_2 \cdot 6H_2O$, $Ca(OH)_2$) brightens the pigment due to the formation of phases of zinc and calcium vanadates.

The use of marshallite as a substrate can reduce the cost of synthesized pigments.

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REFERENCES

[1] A.G. Merzhanov, The concept of the development of self-propagating high-temperature synthesis as the field of scientific and technical progress, Territoriya, Chernogolovka, (2003).