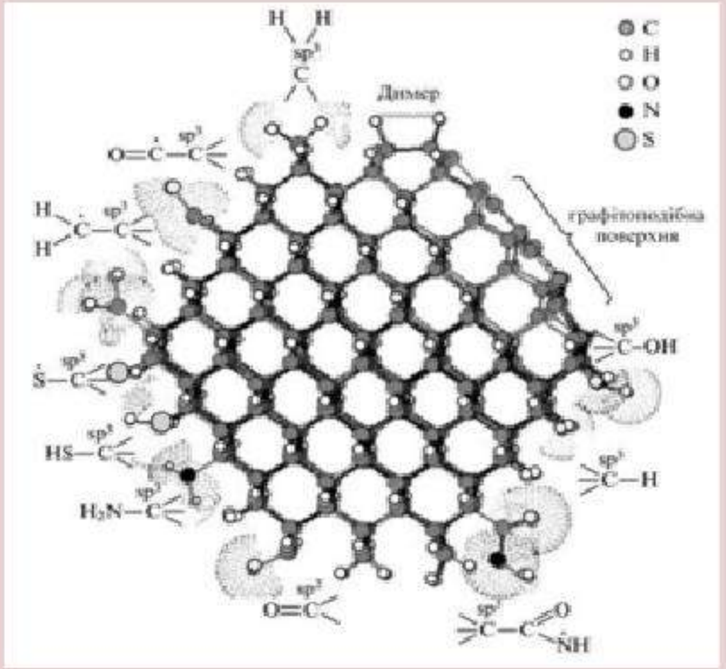
United Nations Educational, Scientific and Cultural Organization

Junior Academy of Sciences of Ukraine

Detonation Nanodiamonds as Part of Smart Composite Paintwork Materials

Elina Kamalova

Relevance of the research



Nanodiamond's surface model with different functional groups

The aim of the research

To study the effect of nanodiamond particle additives on the physical-mechanical and optical properties of nanocomposite paints and coatings for further prediction of their use in various industries.

Objectives of the research

- Production of water-based coatings acrylic dispersion and dispersion with nanoparticles.
- Research of properties of coverings.
- Analysis of experimental results.
- Formulation of recommendations on areas of application detonation nanodiamonds.

Methods of making compositions

Recipe for nanodiamond water paste

№	Components	Amount,%
1.	Water	97,5
2.	Thickener	0,5
3.	Dispersant	0,7
4.	Defoamer	0,3
5.	Nanodiamonds	1,0

Recipe of aqueous acrylic dispersion composition with nanodiamonds

№	Components	Amount,%
1.	Water paste of nanodiamonds	30
2.	Acrylic dispersion	67,7
3.	Acrylic thickener	0,3
4.	Coalescent	2

Made compositions

Water paste recipe

№	Components	Amount,%
1.	Water	98,5
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3.	Dispersant	0,7
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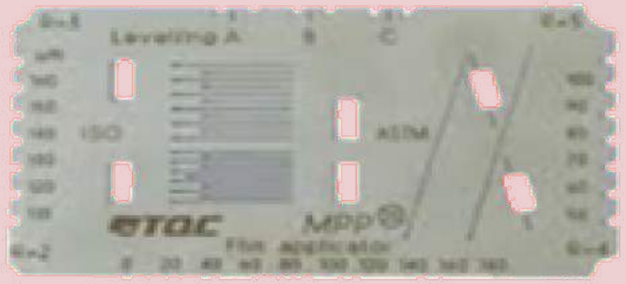
The research methodology of the properties of paints and varnishes

rheological	physico-mechanical	optical
(properties of liquid compositions)	**(properties of the made coverings)**	**(colorimetric properties of coatings)**
conditional viscosity	relative hardness, impact resistance, elasticity, adhesion, thickness, wear resistance	color purity, color tone, brightness

1. Determining the optimal concentration of nanodiamonds for improvement relative hardness of nanocomposite paints and varnishes.
2. Study all other properties for the established optimal concentration.

Equipment for determining the physical and mechanical properties of coatings



Universal template SP3000 (TQC, Netherlands) Adhesion measurement method according to ISO 1518

Device for measuring the resistance of coatings to impact according to ISO 6272

Elasticity scale with cylindrical rods according to ISO 1519

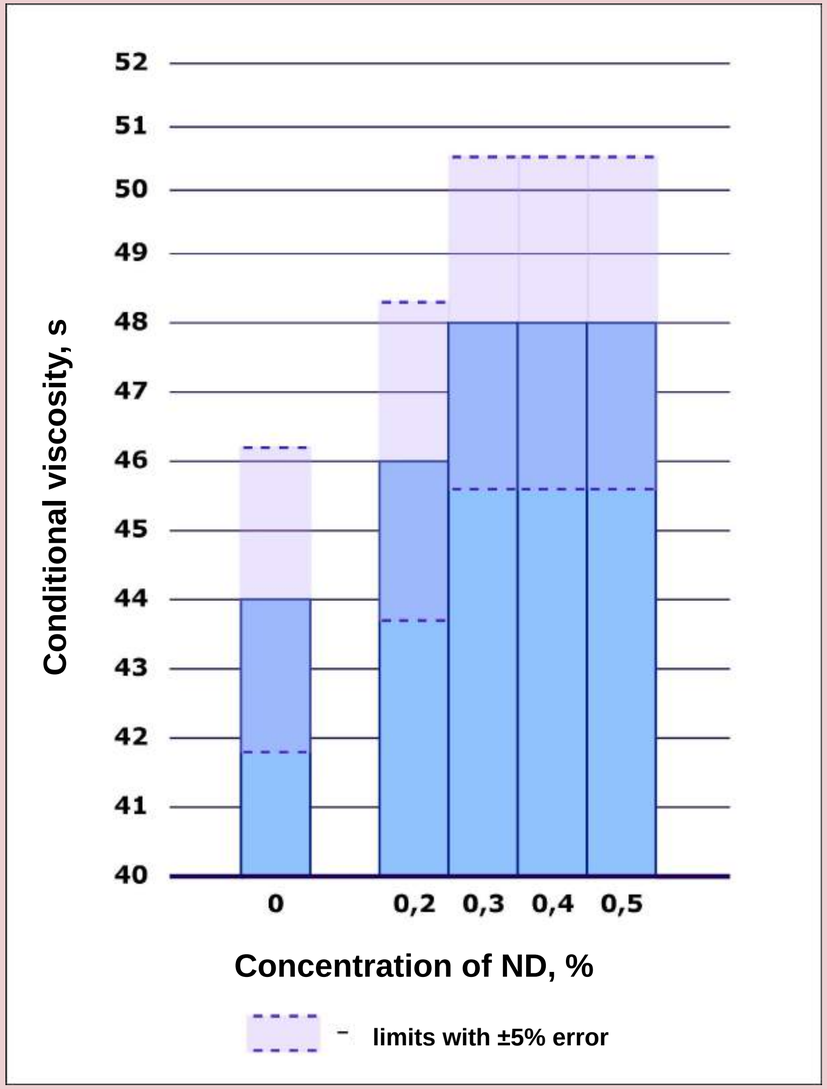
Thickness gauge of a covering of NORVEST TP-1 (L)

Physico-mechanical properties of pure acrylic dispersion (VP) coatings and coatings based on compositions of aqueous acrylic dispersion with nanodiamonds (VPND)

№	Property	VP	VPND
1.	Conditional hardness of coatings, un.	0,38	0,61
2.	Impact resistance of coatings, cm	50	50
3.	Resistance of coatings to bending, mm	2	2
4.	Adhesion of coatings, points	0	0

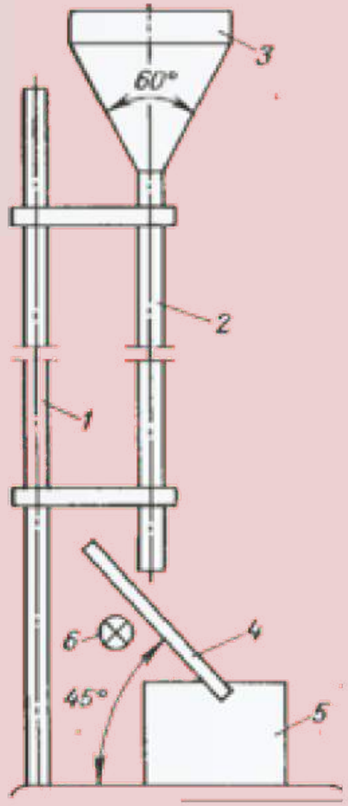
The research of rheological properties

NOVOTEST viscometer (B3-246). ISO 4624 conditional viscosity measurement methods



The results of the study of the concentration dependence of the conditional viscosity on the content of nanodiamonds indicate an increase in this indicator with increasing concentration of nanodiamonds in nanocomposite paints up to 0.3%.

Determination of wear resistance of coatings



Installation for determining the wear resistance of coatings

1 - tripod;
2 - tube;
3 - crater;
4 - coated glass photographic plate;
5 - quartz sand tank;
6 - illuminator.

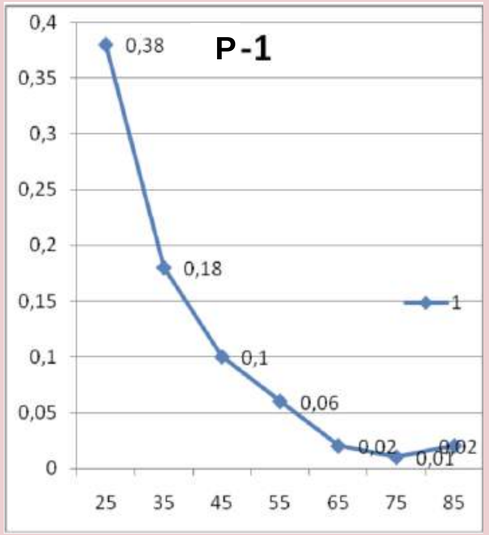
Changes in the weight of coatings during the wear resistance measurement

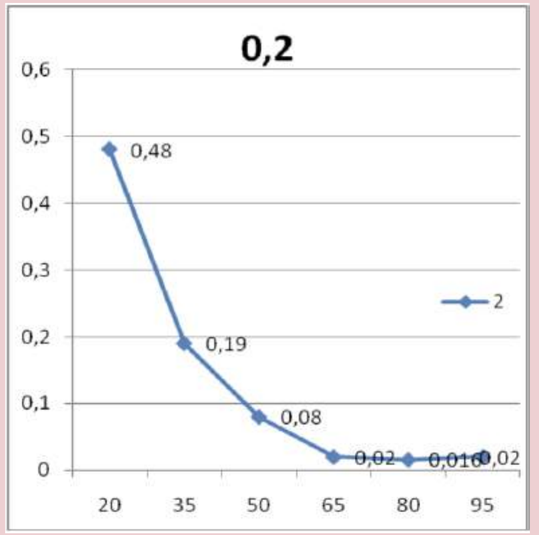
The sample	Initial weight of coated glass photographic plates, g	Weight of coated glass photographic plates after the research, g	The weight loss, Δm, g	The wear resistance kg/kg $\Delta m/m_{sand}$
Dispersion with nanodiamonds	36,9544	36,9370	0,0174	$1,58 \cdot 10^{-7}$
Pure dispersion	36,9637	36,9482	0,0155	$3,8 \cdot 10^{-7}$

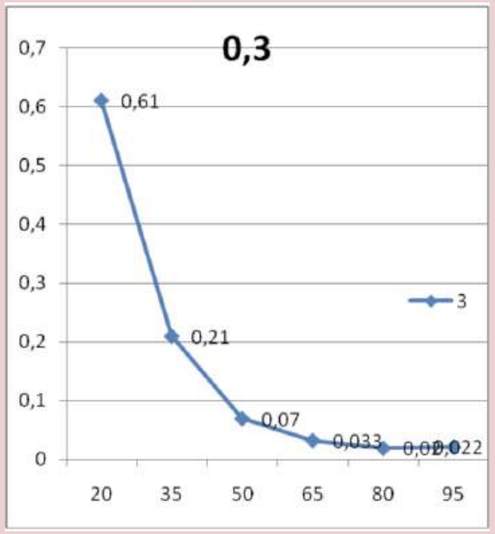
Wear resistance of coatings with nanodiamonds is higher than coatings based on acrylic aqueous dispersion without nanodiamonds on: $(3,8-1,58) \cdot 10^{-7} \cdot 100\% / (3,8 \cdot 10^{-7}) = 58\%$.

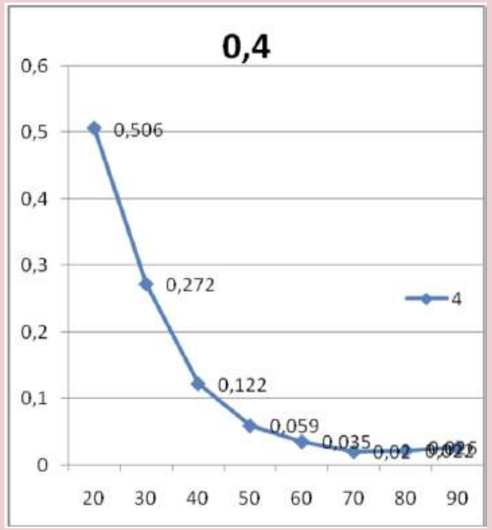
Temperature dependences of conditional hardness of coatings with the different content of nanoparticles

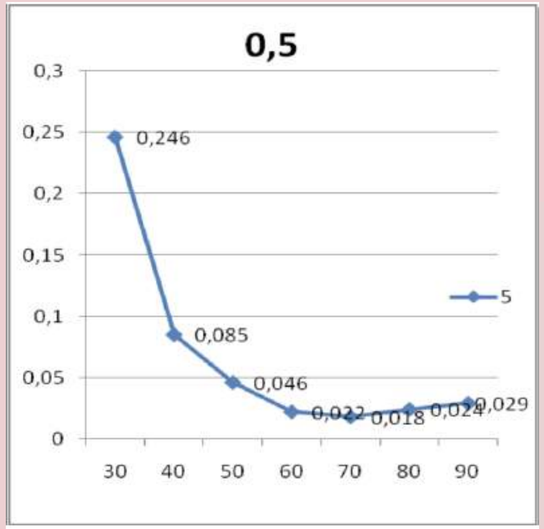
Pendulum hardness tester
(TQC, Netherlands) SP0500 with the König pendulum (TQC, Netherlands), the Persoz pendulum (TQC, Netherlands) SP0510-349
Method of measurement according to ISO 1522



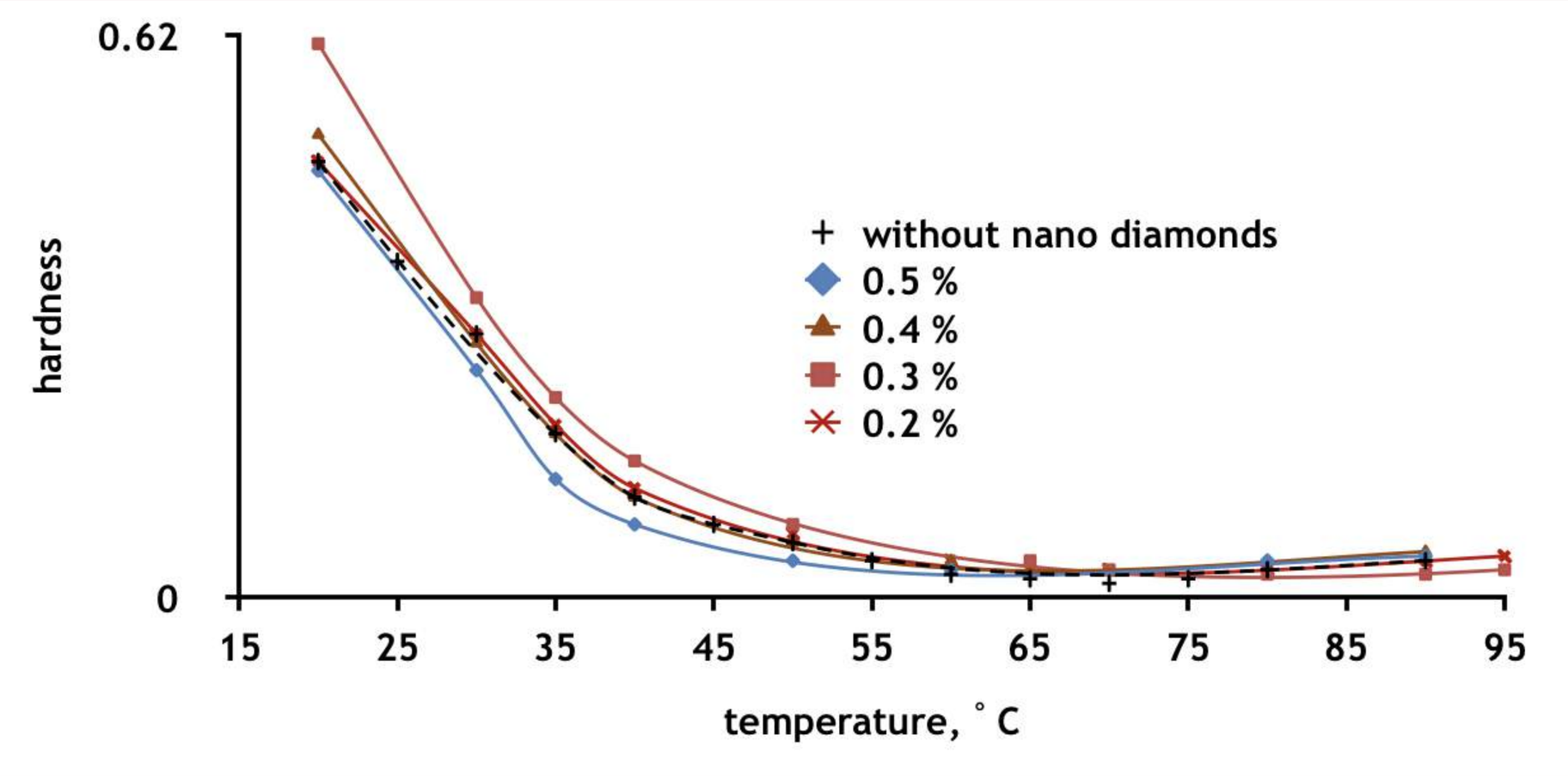




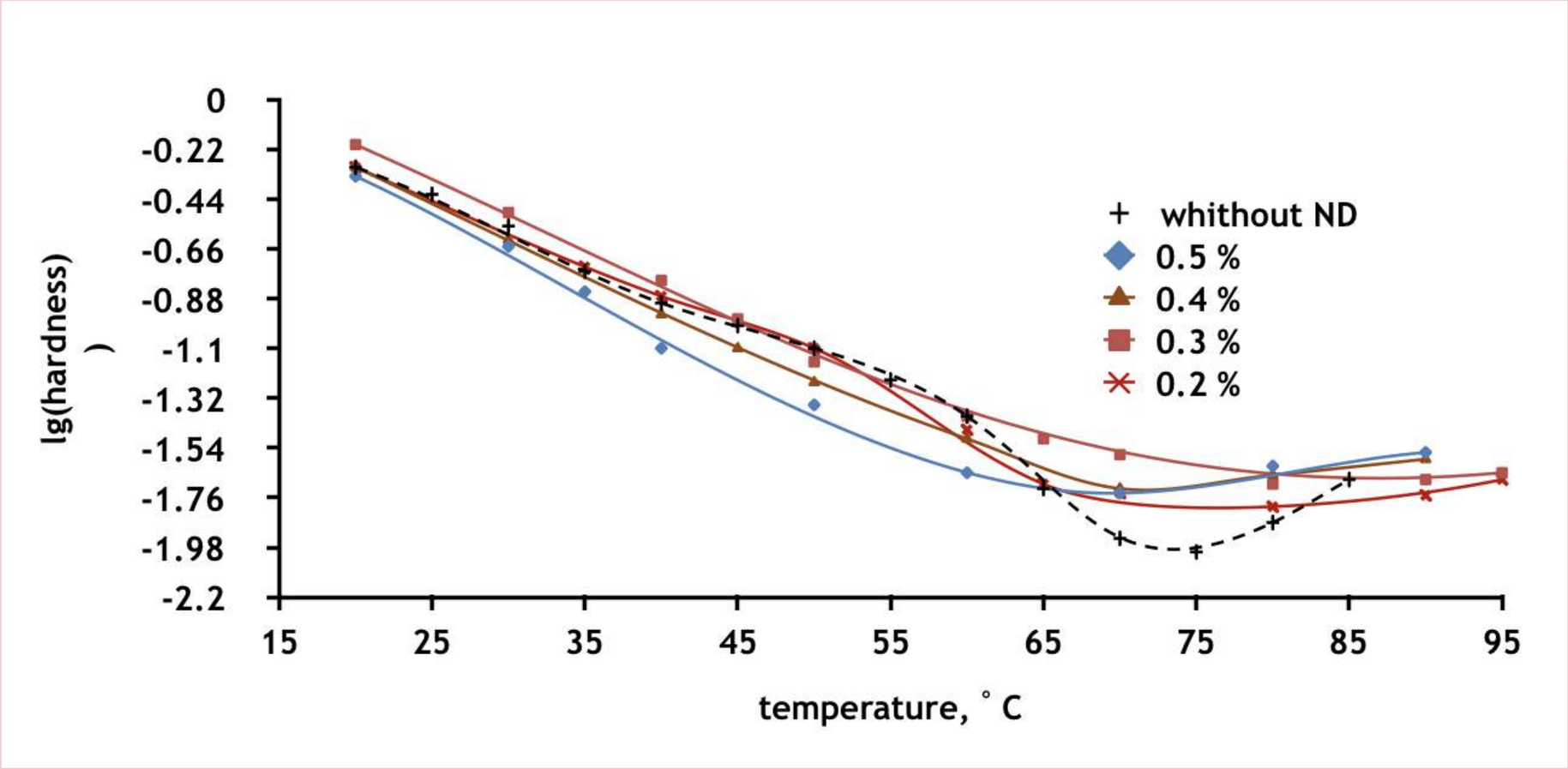




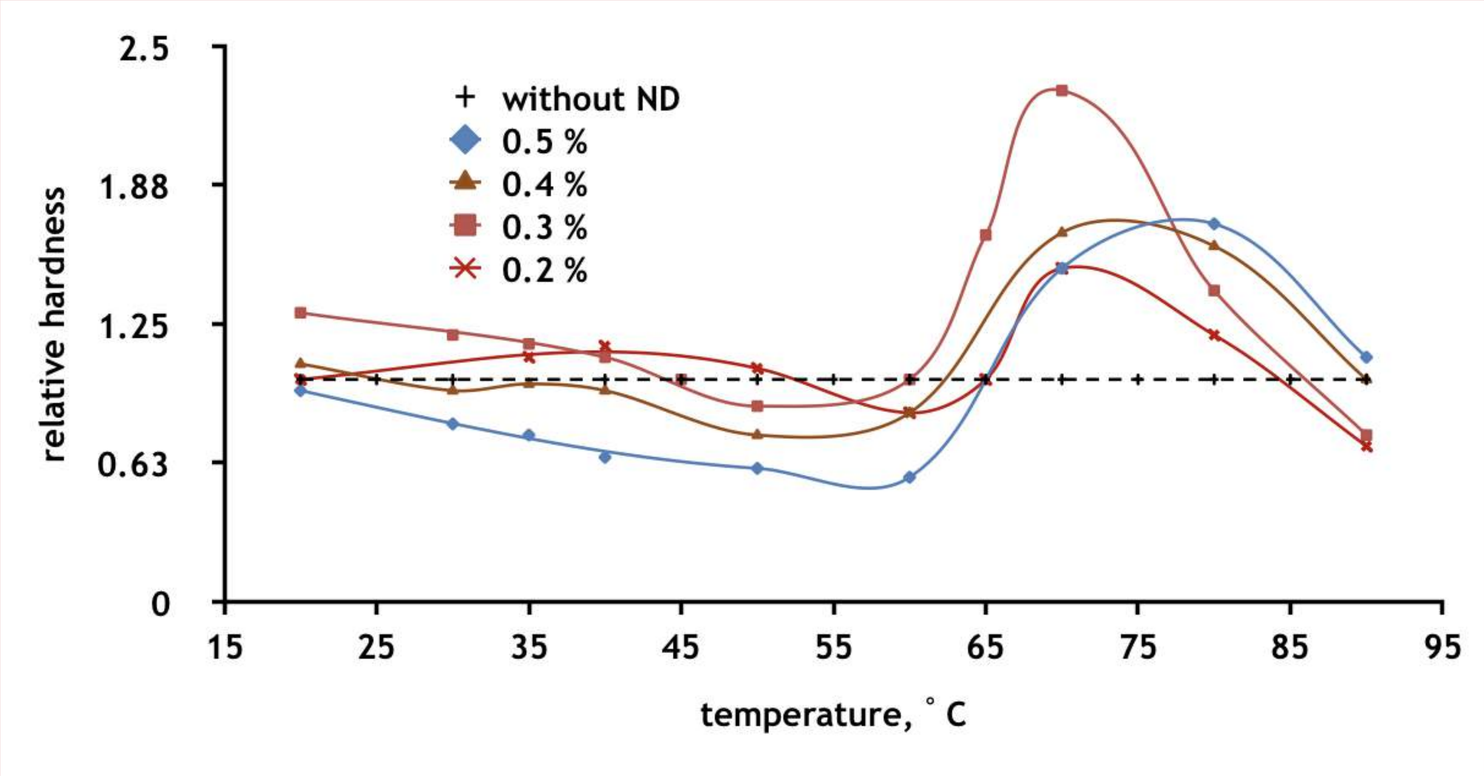
Temperature dependences of conditional hardness of coatings depending on the content of nanoparticles



Logarithmic dependence of the hardness of coatings on the content of nanodiamonds



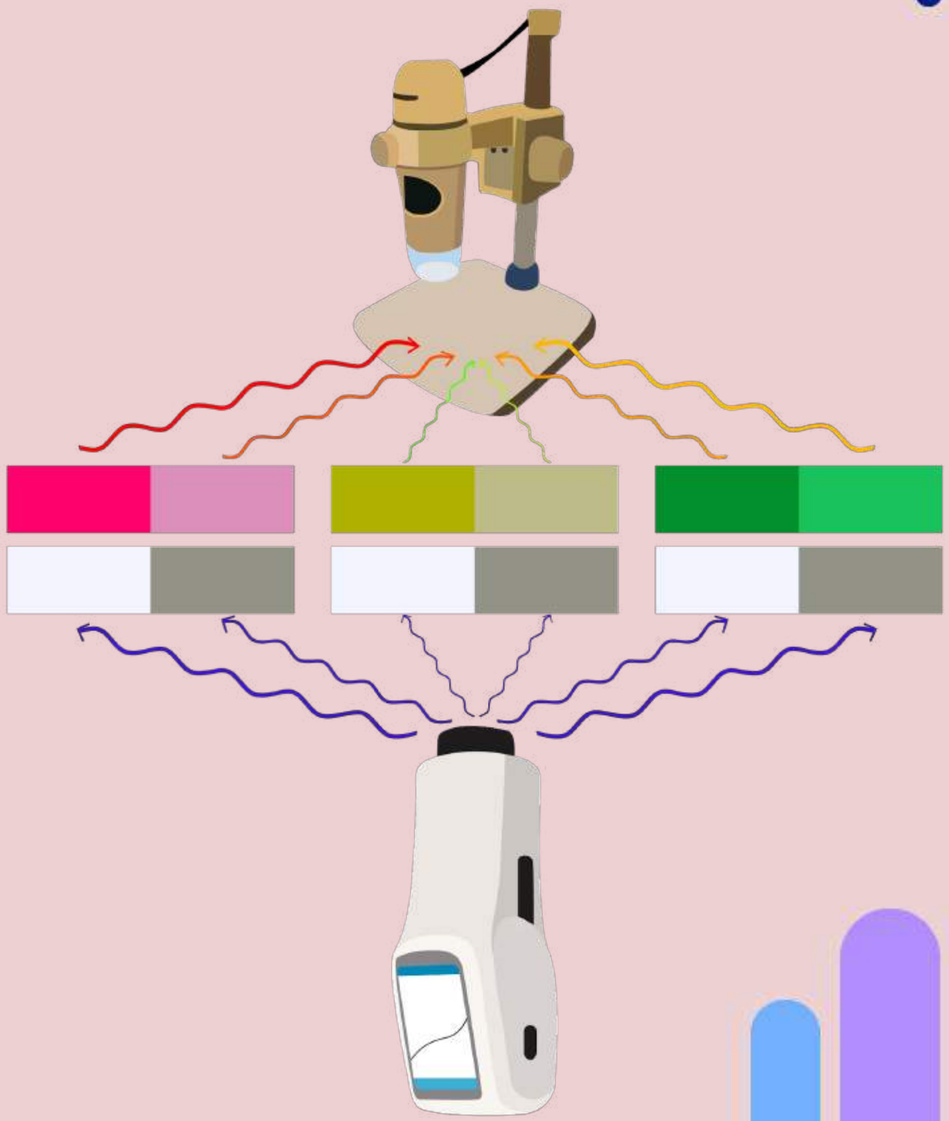
Temperature dependence of hardness in relative units (in relation to the sample without nanodiamonds)



It was determined that the optimal amount of nanodiamonds is 0.3%, providing a 2.4-fold increase in the hardness of the coating.

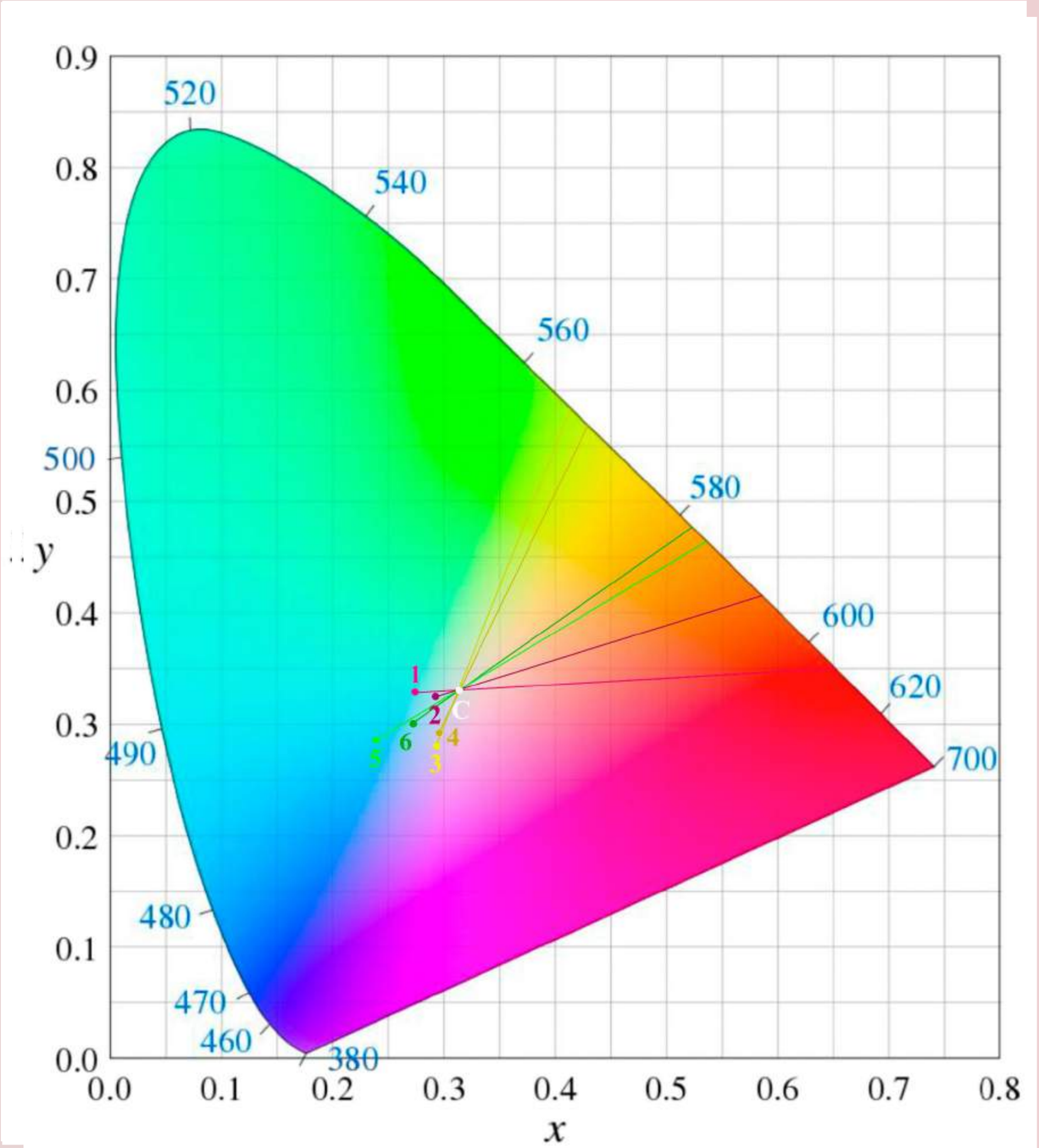
Determination of optical properties of coatings
(concentration of nanodiamonds - 7%)

Portable spectrophotometer NS810



Color parameters of the studied pigments under UV radiation

№	Type of the sample	XYZ	CIELAB	λ, P ,Y
1.	Red	X = 4,1058 Y = 4,9670 Z = 5,9987	L = 22,85 A = -2,4 B = 5,14	λ=607, P=11,71%, Y=4,9670 
2.	Red with ND	X = 5,1421 Y = 5,7497 Z = 6,7832	L = 27,91 A = -0,17 B =-2,14 ΔE = 9,15	λ=593, P=8,70%, Y=5,7497 
3.	Yellow	X = 26,2291 Y = 25,0617 Z = 38,1268	L = 57,14 A = 7,77 B = -11,87	λ=565, P=22,22%, Y=25,0617 
4.	Yellow with ND	X = 29,1135 Y = 28,5971 Z = 40,1755	L = 60,42 A = 5,1 B = -8,63 ΔE = 5,5	λ=568, P=15,79%, Y=28,5971 
5.	Green	X = 11,6266 Y = 13,8998 Z = 23,3076	L = 40,04 A = -12,72 B = -13,49	λ=583, P=34,12%, Y=13,8998 
6.	Green with ND	X = 16,5657 Y = 18,3176 Z = 26,0161	L = 49,88 A = -6,83 B = -7,88 ΔE = 10,01	λ=585, P=20,48%, Y=18,3176 



The chromaticity diagram

Conclusions

- As a result of studying the effect of detonation nanodiamonds on the physical-mechanical and optical properties of water-dispersion paints, it was found that the introduction of nanodiamonds leads to significant increase in the conditional hardness of the coating (almost 60%) and wear resistance (almost 140%) and almost does not change the viscosity of the suspension.

- It was determined that the optimal amount of nanodiamonds is 0.3%, providing a 2.4-fold increase in the hardness of the coating, and the most effective effect of nanodiamond additives on the hardness of coatings for temperatures of 60-80 °C.

- Based on the results of the experiments, a simple mathematical model was proposed for the dependence of the coating hardness on the concentration of nanodiamonds in suspension and temperature.

- As a result of the research, the possibility of creating an effective UV radiation filter based on paint coatings with the inclusion of nanodiamonds has been proved. Therefore, the results of the study make it possible to recommend the use of detonation nanodiamonds in various industries both to improve the performance properties of paint coatings and to create new optical materials in the field of UV radiation.

Thank you for your attention!