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NANOTECHNOLOGIES

POLYDEF - antibacterial nanoadditive to polymers

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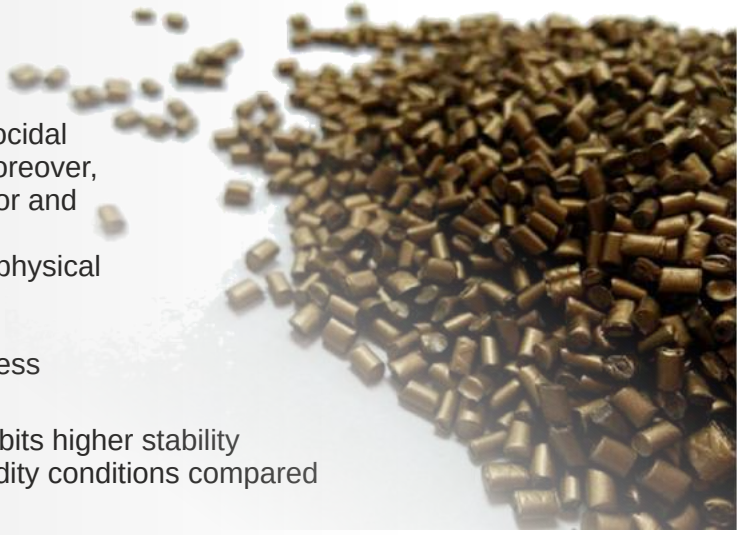


POLYDEF is a specially designed component for polymers, based on silver nanoparticles (Ag) and silica (SiO_2), ensuring antibacterial and antifungal properties of the final material. Presence of nanosilver in the protected polymer provides a biocidal e ect through inhibition of pathogen`s metabolic pathways. Moreover, it contributes to the elimination of the source of unpleasant odor and prolongation of the product lifetime.
The additive is environmental-friendly and does not a ect the physical properties or induce degradation of the protected material.
The component assures **long-term antimicrobial protection** (e ectiveness ≥ 99.98%) and increases safety and attractiveness of the product.

Importantly, nanoadditive exhibits higher stability at high temperature and humidity conditions compared to traditional biocidal agents.

O er includes:
- nanoaddtive in the form of powder (10% of nanosilver)
- masterbatch (0,5% of nanosilver)

Technical parameters and properties

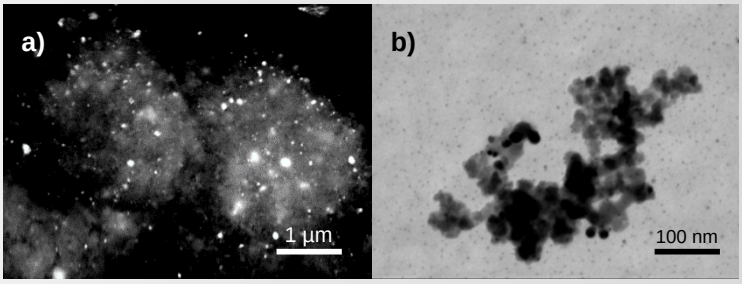
Table 1. Technical parameters and properties of nanoadditive in the form of powder and masterbatch.

Property	Nanoadditive	Masterbatch with nanoadditive
Form	yellow powder	yellow-brown granulate
Silver content	10%	0.5%
Dosage	5%	1-3%
Carrier	SiO_2	polymer granulate (HDPE, LDPE, PP, ABS, EVA, PET)
Application method	mix product in the form of powder with the polymer through embossing, according to typical for the polymer processing parameters	mix product in the form of masterbatch according to typical for the polymer processing parameters; easy application without technological line modification
Smell	none	
Expiration date	2 years	
Application	Polymeric elements exposed to the pathogens colonization: - **construction materials** (roof foils, pipes); - **household appliances cover** (fridges, washing machines, keyboards, pin-pads); - **plastic elements in the public space** (light switches, handles, toi-tois); - **packaging** (for eco-cosmetics); - **personal products** (shoes, watches, pulsometers); - **hospital equipment** (beds) - and many others.	

Nanoadditive morphology and composition

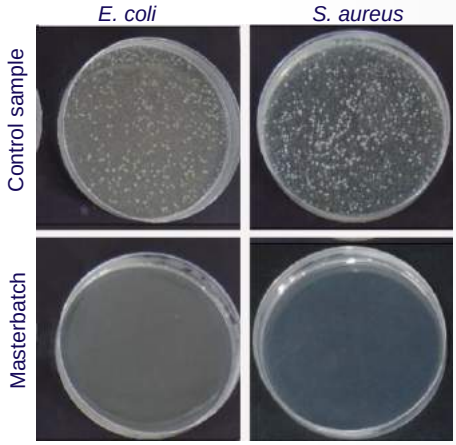
Dimensions, morphology, and composition of silver and silica nanocomposite were investigated via scanning (SEM) and transmission electron microscopy (TEM). SEM/BSE micrograph (picture 1a) presents micrometric agglomerates of silica and silver nanoparticles (from a few to a dozen nanometers) depicted as bright spots. Uniform distribution of silver on silica support was confirmed. X-Ray microanalysis revealed 10% silver content.

The presence of ceramics agglomerates (from several hundreds of nm to few µm) was also observed on TEM pictures (picture 1b). Silver nanoparticles are visible as spherical dark points.



Picture 1. SEM/BSE (a) and TEM (b) micrographs of the nanoadditive.

Antimicrobial activity



Picture 2. Antibacterial activity of PP element with 0.01% nanosilver.

Antibacterial activity of the polypropylene element with 0.01% of nanosilver was tested according to international norm **ISO 22196** ("*Plastics – Measurement of antibacterial activity on plastic surface*") (picture 2).

The experiment was performed on two bacterial strains: *Staphylococcus aureus* (ATCC 25926) and *Escherichia coli* (ATCC 25922). For both of the tested microorganisms, the number of viable colonies reduction after 24 h incubation reached **≥ 99.98%** (table 2).

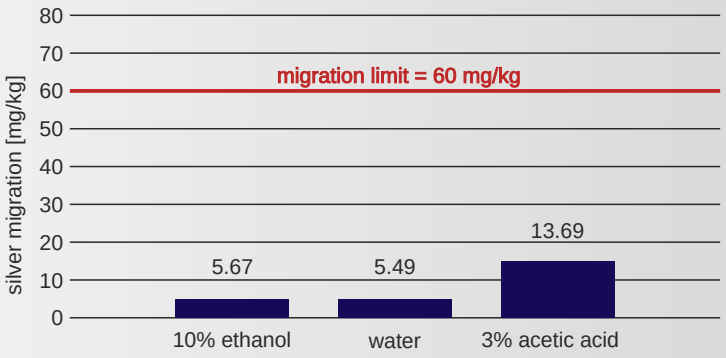
Table 2. Antimicrobial e ectiveness of PP element with 0.01% of nanosilver.

Sample	Antimicrobial activity [log]	Reduction of bacteria [%]
E. coli	4.27	100.00
S. aureus	3.61	99.98

Silver specific migration

In order to assess safety of the nanoadditive application, the specific silver migration to model fluids test was performed according to international norm **PN-EN 1186**. The experiment was conducted for masterbatch with 0.5% silver content.

The overall migration limit is **60 mg/kg**. For all model fluids, the silver migration level is much lower than indicated upper limit (picture 3). It is worth pointing out, that in the final product silver content is 50 times lower and therefore potential migration much less significant. It clearly confirms the **safety of nanoadditive application.**



Picture 3. Silver migration to model fluids from granulate with 0.5% nanosilver content.

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