ENVIRONMENTAL PROBLEMS

Vol. 5, No. 4, 2020

DEVELOPMENT OF DETERGENT RECIPE WITH IMPROVED ENVIRONMENTAL CHARACTERISTICS

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https://doi.org/10.23939/ep2020.04.223

Received: 9.10.2020

Abstract. The research on the development of an innovative formula of a synthetic detergent with improved environmental properties, which meet the environmental standard of SOU OEM 08.002.12.065:2016 "Detergents and cleaning products. Environmental criteria for life cycle assessment" is carried out. The accumulated theoretical and practical experience is generalized, the general scheme of designing and development of new goods taking into account features of detergents with the improved ecological characteristics is created.

Key words: innovative formula, synthetic detergents, ecological properties, ecological standard, resource-saving production.

1. Introduction

Household chemicals are one of the most promising among other non-food products and have a certain trend of development due to the development of new raw materials and modern production technologies. The Ukrainian market offers a wide range of different tools, but the chemical composition of this type of product is quite similar. Detergents are usually based on surfactants and auxiliary components containing carcinogens, toxins, allergens, etc. At the same time, detergents on a natural basis are limited.

Detergents can pollute the air in the room, irritating the mucous membranes of the eyes, nose and throat. They cause headache and dizziness. Most detergents contain hazardous ingredients that remain on the fabric even after rinsing. Besides, detergents can cause significant damage to the environment, disrupting aquatic ecosystems. When entering the reservoir, there is an intensive reproduction of algae, especially blue-green, which in the process of their biological development reduce the oxygen content in the water, form toxic substances and cause mass death of hydrofauna. Phosphates, which enter the sewage treatment plants of biological type in high concentration with sewage, completely suppress the biological functions of activated sludge microorganisms. A lot of chemicals that are a part of the product easily pass through water treatment systems and after getting into open water systems return to the city's water supply system.

Taking into account all the consequences, the number of conscious consumers is growing every day and the safety indicators of detergents become a determining criterion when choosing a product.

Therefore, the authors decided to develop an innovative formula of synthetic detergent with improved environmental properties that meet the environmental standard. The analysis and use of standard methods showed that for comparative studies for this group of products reference samples and standards DSTU and TU U 24.5-36385435-001: 2011 can also be used, as they allow to assess the basic properties of synthetic detergents.

2. Theoretical part

The theoretical and methodological basis of the study are scientific works in the field of technological processes of detergent production, by scientists K. Lange, M. Pletnev, F. Nevolin, A. Abramzon, G. Stupel, M. Platonov, V. Donchak, O. Dzevochko. The subject of their research was the production technology, classification of synthetic means, etc. S. Vilkova, J. Kehler, I. Volnov, A. Abramzon, Z. Buchstab, F. Nevolin in their studies in the late twentieth century determined the typical chemical composition of detergents. Component and technological characteristics

of the new generation of detergents are described in the works of such scientists as A. Sharova (silicone surfactants), V. Kasilovich (liquid detergents); M. Pletnev (cosmetics and hygiene products), etc.

The methodology of evaluation of detergents according to different qualitative parameters is based on the works by such foreign scientists as M. Buckman, T. Lindqvist, A. Tidel, P. Heidenmark, K. Johnson, K. Alto, E. Gaiskanen, S. Laire [18], whose research interests are mainly in experimental and component verification of compliance of the detergents with environmental standards. Works by such scientists as S. Matsunaga, J. Nago, T. Mukayama; V. Makityansky, V. Davidyuk; L. Mayurnikova, O. Gabinska, N. Dvoretskaya; V. Ivantsov, are devoted mainly to the effectiveness of individual components of detergents or surfactants and were used in developing a synergistic effect of the joint activity of the components of detergents. In particular, the achievements of G. Moel (dynamic interphase properties of low-foam surfactants), J. Novak (secondary alkane sulfonates in household chemicals), O. Vyglazova (development of fragrance formulations for household chemicals); N. Divakova (appropriate use of enzymes in detergents); A. Kotomin (the study of washing efficiency), etc. were used.

Strategies for the development of chemical industry enterprises were studied by N. Hrytsiuk, M. Barna; K. Muratova, O. Pirikov, V. Rybachenko. The principles of new ecological consciousness and the conformity of the products to the newly adopted standards are reflected in the research of Yu. Slyva, P. Nikolaeva, S. Berzina, E. Pokhodila, A Zoria, etc.

Separate components of detergents are in the circle of scientific interests of domestic chemists. Scientists are studying the properties of compounds and developing alternative methods for their synthesis while drawing a parallel between the feasibility of using them for the production of detergents in the future. Thus, M. Platonov notes that derivatives of sulfonic acids attract attention of scientists because they are widely used in the production of antimicrobial drugs for antifungals and detergents. V. Donchak, having analyzed a number of topical scientific publications, noted that “gemini” surfactants (surface-active oligomers) are increasingly used as effective detergents. O. Dzevochko, was engaged in the creation of the diffusion-controlled process of oxidation of low-concentration SO2 under pressure to obtain a sulfating agent in the production of surfactants in the reactor. About 80 % of their number is used in synthetic detergents.

Economists, as a rule, study the market of household chemicals and develop theoretical provisions, methodological approaches and practical recommendations for the formation of strategy for the development of chemical industry enterprises (NO Gritsyuk, PG Pererva, VV Oleshko, M. Yu. Barna). A separate area of research concerns the non-domestic use of detergents (in technology, agriculture) and their impact on the objects of this industry.

A separate area is marketing and legal research, which examines the problems related to expanding the range of products, improving its composition and more. However, most research has focused on the environmental aspect, as required by the state-chosen security vector of the “Ukraine 2020” Sustainable Development Strategy, which calls for special attention to be paid to a safe environment and access to quality drinking water, safe food and industrial goods. The new ecological consciousness of citizens places appropriate demands not only on household products but also on all national producers who could compete in the foreign market.

3. Results and Discussion

3.1. Properties of a detergent with improved environmental performance

The development of a detergent with improved environmental performance can include almost all stages of design and formation of the product quality. Companies that have experience in creating new products, modify the product in their laboratories. New enterprises focus on independent organizations and suppliers of raw materials. Suppliers, as a rule, are interested in constant modification of products for the sake of its competitiveness and compliance with constantly changing consumers' requirements.

It is possible to reasonably determine the need for modification and the optimal degree of novelty of the product only as a result of expert research. We conducted such research during the design and development of detergents with improved environmental performance.

For this purpose, a number of properties of a detergent with improved environmental characteristics have been identified, which determine its main environmental, hygienic and functional values:

1 Appearance.

2 Colour.

3 Smell.

4 The concentration of hydrogen ions in 1 % aqueous solution (pH unit)

5 Washing ability (%).

6 Mass fraction of dust (%).

7 Ash content of cotton fabric after 25 washing cycles (%).

8 Decrease in durability of cotton fabric after 25 cycles of washing (%)

9 Foaming ability: foam height (cm).

10 Biodegradability of surfactants (%).

3.2. Development of a basic recipe

Most of the consumer properties that determine the basic values of detergents are formed during the development of the recipe. The development of a detergent formulation with improved environmental characteristics began with the formation of basic composition. Based on the analysis of literature data, raw material proposals, taking into account modern environmental standards for the production of synthetic detergents and the study of the properties of the components, the basic formulation of washing powder "Universal" was proposed (Table 1):

Table 1

Recipe No. 1, washing powder "Universal"

No.	Name of raw material	Mass fraction, %
1	White salt	29.0
2	Soda ash	30.0
3	Tripolyphosphate	15.0
4	Sodium percarbonate	8.0
5	Linear alkylbenzenesulfonic acid – ABSA	5.0
6	Ethoxylated fatty alcohols	3.0
7	Oxygen bleach activator	2.0
8	Liquid glass	4.0
9	Liquid potassium soap	2.0
10	Antiresorbent – sodium salt of carboxymethylcellulose	0.5
11	Optical bleach	0.0
12	Natural flavour	0.1
13	Demineralized water	1.0

In order to improve consumer properties, the composition was optimized. For this purpose, the influence of the main and a number of auxiliary components on the washing ability was studied, as it is a mandatory indicator and depends on the correctly selected system of components that are part of the detergents. The increase in functional properties can be achieved by introducing such components as complexing agents. In the course of the research, it became clear that a properly selected system of complexing agents can significantly increase the washing ability. Simultaneously with the strengthening of the washing effect, the complexing agents prevent the deposition of minerals on the heating elements of the washing machine, as well as on the laundry, which gives it a grey tint.

In order to make a washing powder with the working name "Universal" and taking into account the above recipe and all technological, environmental and resource-saving requirements, the following sequence of actions and the course of the production process are proposed (Table 2).

Table 2

Components and course of the technological process for manufacturing the washing powder "Universal"

Reactor-mixer for the manufacture of powders	
Soda ash	Turn on the stirrer Stir for 5 minutes
White salt	
Tripolyphosphate	
Ethoxylated fatty alcohols	Stir for 5 minutes
Liquid soap	
Soda ash	Stir for 2–3minutes
ABSA	
Oxygen bleach activator	Stir for 3–5 minutes
Soda ash	
Optical bleach	
Antiresorbent	
Liquid glass + water	Stir for 5–10 minutes
Sodium percarbonate	Stir for 3–5 minutes

3.3. Powder with improved environmental performance

Sodium tripolyphosphate is widely used in the production of powdered synthetic detergents. However, low solubility and poor environmental effect in water make it difficult to use the detergents with improved environmental performance. Therefore, instead of phosphorus-containing complexing agents, combinations of sodium gluconate, polycarboxylate and ethylenediaminetetraacetic acid derivatives were used. Based on the above data, the following recipe No. 2 of the powder with improved environmental performance is proposed (Table 3).

The course of the technological process of the production of this experimental brand of powder is presented in Table 4.

During the process, it was found that ethylenediaminetetraacetic acid derivatives and sodium gluconate bind the salts that create water hardness and soluble complexes, and polycarboxylates prevent the re-deposition of suspended dirt particles on the cleaned surface. The use of these components separately in the formulation of liquid detergents leads to an increase in the washing ability only up to 30–42 %. The combined action of both components allows for increasing the washing ability up to 72 %.

Therefore, adding complexing agents and polycarboxylate to the system at the same time significantly increased the washing ability (Fig. 1–2)

Table 3

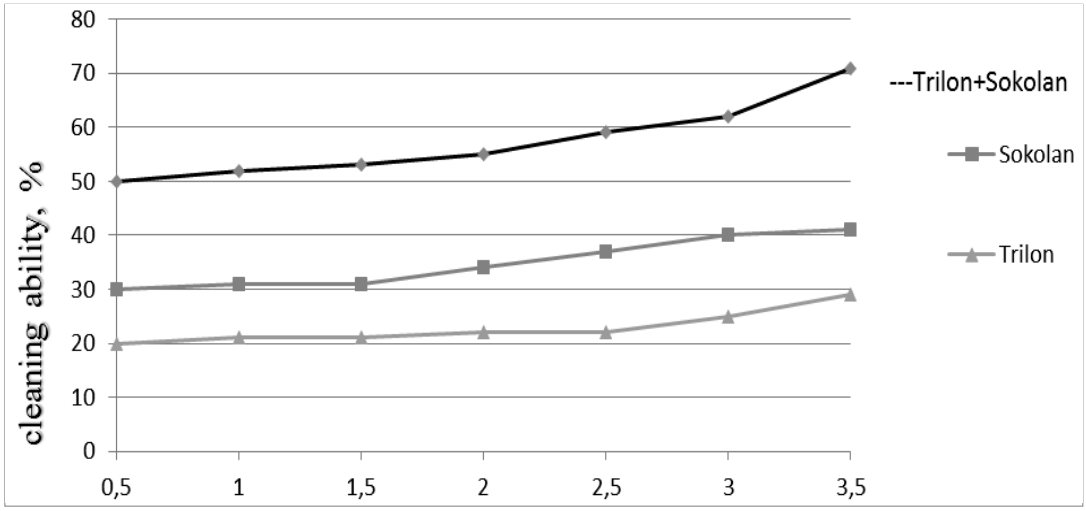
Recipe No. 2 with the replacement of zeolites with an **ecological complexing agent, the introduction of baking soda and enzymes**

No.	Name of raw material	Mass fraction, %
1	White salt	32.0
2	Soda ash	32.0
3	Sodium gluconate	3.0
4	sodium bicarbonate	5.0
5	Sodium percarbonate	8.0
6	Linear alkylbenzenesulfonic acid - ABSA	5.0
7	Ethoxylated fatty alcohols	3.0
8	Oxygen bleach activator	2.0
9	Liquid glass	4.0
10	Liquid potassium soap 38 %	3.0
11	Enzymes	0.3
12	Antiresorbent - sodium salt of carboxymethylcellulose	0.5
13	Optical bleach	0.1
14	Natural flavour	0.1
15	The water is demineralized	2.0

Table 4

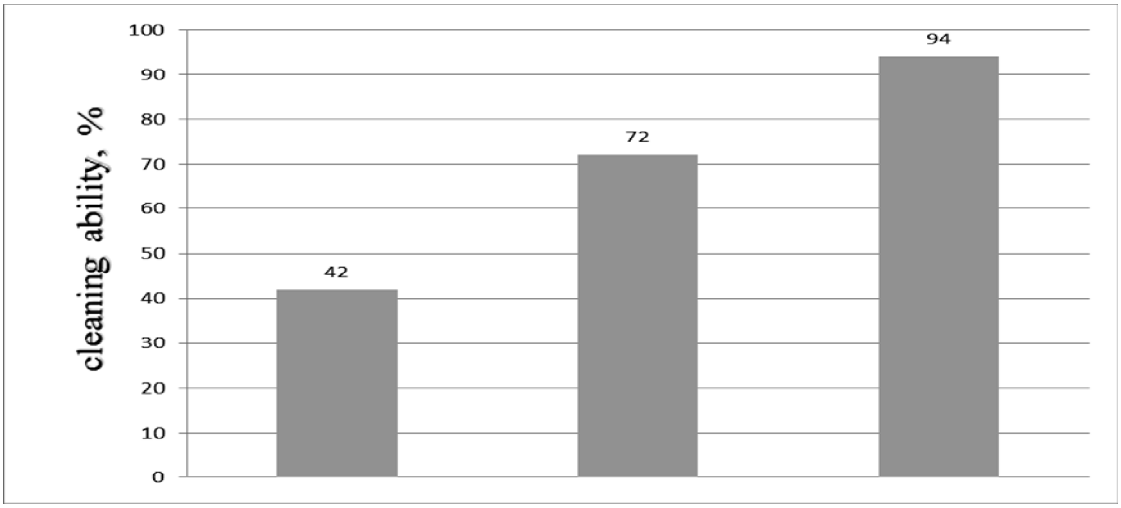
Components and course of the technological process for manufacturing washing powder according to recipe No. 2 (with the replacement of zeolites with the ecological complexing agent, the introduction of baking soda and enzymes)

Reactor-mixer for manufacturing powders	
Soda ash	Turn on the stirrer Stir for 5 minutes
White salt	
Sodium gluconate	
sodium bicarbonate	
Ethoxylated fatty alcohols	Stir for 5 minutes
Liquid soap	
Soda ash	Stir for 2–3 minutes
ABSA	
Oxygen bleach activator	Stir for 3–5 minutes
Enzymes	
Soda ash	
Optical bleach	
Antiresorbent	
Liquid glass + water	Stir for 5–10 minutes
Sodium percarbonate	Stir for 3–5 minutes
Natural flavor	



Concentration, %

Fig. 1. The effect of complexing agents on the washing ability of liquid detergents (temperature 50 ° C, pigment-oil contamination)



Concentration, %

Fig. 2. Synergistic effect of phosphate-free agents "Trilon", "Sokolan" and soap on detergency

Determination of proteolytic activity showed that soap is additionally a stabilizer of enzymes, thereby reducing their proteolytic decomposition. The introduction of baking soda prevents the "caking" of the powder, and enzymes are an important adjunct to most synthetic detergents. When developing a product containing enzymes, special attention should be paid to the problem of stabilization of these additives during long-term storage. The stability of the enzymes is affected by the acidity of the medium, the water content and the composition of the surfactants used. It is known that anionic surfactants reduce the stability of enzymes, nonionic surfactants have a certain stabilizing effect, and cationic surfactants are not compatible with enzymes.

Recipe No. 3 with the replacement of alkynbenzenes and alkynphenols with environmentally friendly component.

According to the requirements of SOU 065, environmentally friendly household chemicals should not contain surfactants based on alkylbenzenes and alkylphenols. Therefore, in the framework of the above recipe was the replacement of ABS and antiresorbent with more effective (Table 5). Based on this component modification, recipe No. 3 was developed.

The course of the technological process for manufacturing detergents according to recipe No. 3 are presented in Table 6.

Table 5

Recipe No. 3 with the replacement of alkynbenzenes and alkynphenols with environmentally friendly components

No.	Name of raw material	Mass fraction, %
1	White salt	28.0
2	Soda ash	32.0
3	Sodium gluconate	3.0
4	sodium bicarbonate	5.0
5	Sodium percarbonate	8.0
6	Sodium alpha-olefin sulfonate 38 %	8.0
7	Ethoxylated fatty alcohols	3.0
8	Oxygen bleach activator	2.0
9	Liquid glass	4.0
10	Liquid potassium soap	3.0
11	Citric acid	2.0
12	Enzymes	0.3
13	Antiresorbent – sodium salt of a copolymer of acrylic and maleic acids	0.5
14	Optical bleach	0.1
15	Natural flavor	0.1
16	The water is demineralized	1.0

Table 6

Components and course of the technological process for manufacturing washing powder according to recipe No. 3

Reactor-mixer for the manufacture of powders	
Soda ash	Turn on the stirrer Stir for 5 minutes
White salt	
Sodium gluconate	
sodium bicarbonate	
Ethoxylated fatty alcohols	Stir for 5 minutes
Liquid soap	
Soda ash	Stir for 2–3 minutes
Sodium alpha-olefin sulfonate	
Oxygen bleach activator	Stir for 3–5 minutes
Enzymes	
Citric acid	
Optical bleach	
Antiresorbent	
Liquid glass + water	Stir for 5–10 minutes
Sodium percarbonate	Stir for 3–5 minutes
Natural flavor	

By modifying the technological process, recipes, modification of raw materials, the use of energy-saving technologies, the maximum focus on environmental protection and ensuring sanitary and hygienic standards in accordance with accepted standards, we have proposed the technology of production of washing powders “Royal Powder”. The technology and recipe were tested in the conditions of DeLaMark LLC, which became the experimental basis for this study, and fully complies with the concept of “green office” and technical, environmental and sanitary standards.

Conclusions

Therefore, in order to increase the functional efficiency and development of synthetic detergents with improved environmental performance several recipes have been developed by optimizing the composition. It has been proven that an appropriate change of complexing agents reduces the harmfulness of the product and increases its detergency. The result was the development of three experimental recipes. The developed formulations of experimental samples of powder and

liquid detergents meet the standards of SOU OEM 08.002.12.065:2016 “Detergents and cleaning agents. Environmental Criteria for Life Cycle Assessment” and the national standards of DSTU developed in accordance with them. In terms of functional properties, the products developed and analyzed for compliance with standards outperform typical detergents with lower environmental performance.

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