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THE IMPORTANCE OF BIOLOGICALLY ACTIVE ORGANIC COMPOUNDS IN AGRICULTURE

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Abstract: In recent years, meeting the demand of the national economy for biologically active compounds (BACs), discovering new compounds, developing their production technologies, and implementing them in practice have become one of the most urgent tasks of modern chemistry. Among physiologically active substances, phenoxyalkyl acids and their derivatives exhibit the highest biological activity, which explains their wide range of applications. These compounds are widely used as selective herbicides affecting dicotyledonous plants and are applied on millions of hectares of agricultural land, including cereal crops and pastures.

Urea and carbamic acid derivatives, as well as arylamides of carboxylic acids, occupy a leading position in herbicide production due to their selective action. Compounds such as dichloroalmuurea, dalapon, and chlorinated benzoic acids demonstrate effective herbicidal properties in agricultural practice. In addition, carbamate derivatives, including IFK esters and chlorinated carbamates, show strong insecticidal and herbicidal activities. These compounds are widely used for weed and pest control in various agricultural systems.

Poliurethanes, as high-molecular compounds, are used in the production of resins, fibers, adhesives, coatings, and foams. Many carbamates exhibit significant biological activity, functioning as insecticides and herbicides. Pyrethrins, natural insecticides derived from chrysanthemum plants, and their synthetic analogues (pyrethroids) are also important due to their effectiveness and environmental safety.

Recent studies show that carbamate chemistry is a promising field of organic synthesis, providing highly reactive intermediates for the development of pesticides with herbicidal, fungicidal, insecticidal, nematicidal, and bactericidal properties. Moreover, bis-carbamate derivatives have demonstrated biostimulant activity in agricultural crops such as cucumber, tomato, and cotton, confirming their practical importance in agriculture.

Overall, the research highlights the significance of biologically active carbamate derivatives in agriculture, organic synthesis, and environmental protection, as well as their potential for developing environmentally friendly and economically efficient technologies.

Keywords: Biologically active compounds (BACs); phenoxyalkyl acids; carbamates; herbicides; insecticides; pesticides; pyrethrins; pyrethroids; polyurethanes; selective herbicidal activity; organic synthesis; agricultural biostimulants; bis-carbamates; environmentally friendly technology.

Introduction

In modern agriculture, ensuring high crop productivity and protecting plants from pests, diseases, and weeds have become key challenges for sustainable development. In this context, biologically active organic compounds play a crucial role due to their ability to regulate physiological processes in plants, control harmful organisms, and improve agricultural efficiency.

Biologically active organic compounds include a wide range of substances such as herbicides, insecticides, fungicides, growth regulators, and biostimulants. These compounds exhibit high biological activity even at low concentrations, making them highly effective tools in agricultural practice. Among them, carbamates, phenoxy acids, pyrethroids, and other synthetic and natural derivatives are widely used in modern agrochemical technologies.

The increasing demand for environmentally friendly and high-yield agricultural production has intensified research into new biologically active compounds with selective action and low toxicity. Such compounds not only enhance crop protection but also minimize negative impacts on soil, water, and non-target organisms, contributing to ecological balance.

Organic chemistry provides the scientific basis for the synthesis, modification, and application of these biologically active substances. The relationship between molecular structure and biological activity is a key factor in designing effective agrochemical agents. Therefore, understanding the chemical nature and functional properties of these compounds is essential for developing innovative solutions in agriculture.

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This study focuses on the importance of biologically active organic compounds in agriculture, their classification, and their practical applications in improving crop yield and plant protection systems.

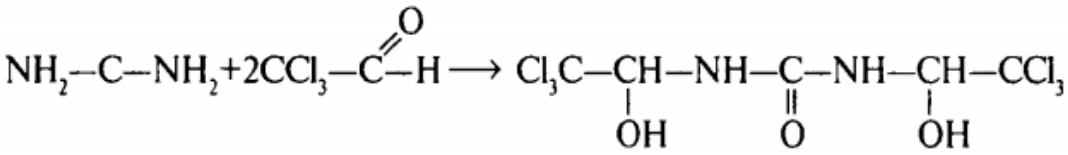
Discussion a nd Results

Currently, meeting the demand of the national economy for biologically active substances, searching for new compounds, developing their production technologies, and implementing them in practice are considered among the most urgent tasks of modern chemistry.

Among physiologically active substances, phenoxyalkyl acids and their various derivatives exhibit the highest level of biological activity. Therefore, their application scope is extremely wide. Compounds belonging to this group affect dicotyledonous plants, and at present they are used for the treatment of millions of hectares of cereal crops and pastures.

Urea and carbamic acid derivatives, as well as arylamides of carboxylic acids, occupy a leading position in herbicide application due to their high efficiency. These compounds belong to the group of selective herbicides and are widely used in agricultural practice.

Dichloroalmuurea — N,N-(bis 2,2,2-trichloro-1-hydroxyethyl)urea. It is synthesized by the reaction of urea with chloral under acidic conditions.



This preparation is intended for use against weeds in sugar beet fields at a rate of 15–20 kg. When applied in large amounts, it may cause eye irritation [1].

Dalapon — the sodium salt of α,α'-dichloropropionic acid (CH_3CCl_2COONa). This compound is a selective herbicide. It is used to eliminate monocotyledonous weeds found among crops such as cotton, sugar beet, maize, and vegetables. When applied to the soil after autumn plowing at a rate of 30–40 kg per hectare, Dalapon provides very effective control against couch grass, one of the most persistent weeds.

Some representatives of aromatic carboxylic acids also possess herbicidal properties, for example, 2,3,6-trichlorobenzoic acid:

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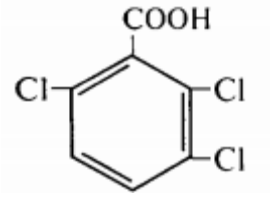
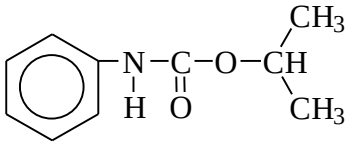


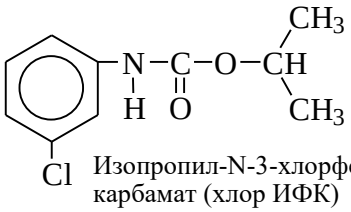
When this substance is applied at a rate of 0.5–5 kg per hectare, it exhibits selective action against perennial weeds growing together with crops such as maize and barley.

Preparations intended for the chemical removal of plant leaves are called defoliants, while desiccants are used to dry out plant foliage [2].

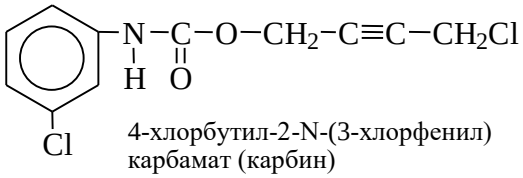
Polyurethanes are high-molecular-weight compounds from which resins, fibers, special rubbers, durable adhesives, surface coatings, and foams are produced. Many carbamates exhibit strong biological activity and demonstrate effective insecticidal and herbicidal properties. Herbicides widely used against annual weeds include IFK esters of carbamic acid, chloro-IFK, and carbin (barban).



Изопропил-N-фенил карбамат (ИФК)



Изопропил-N-3-хлорфенил карбамат (хлор ИФК)



4-хлорбутил-2-N-(3-хлорфенил) карбамат (карбин)

The compound obtained by the reaction of the corresponding phenol with an isocyanate, having the formula Ar–OC(O)NH–CH_2–CH=CH_2, exhibits insecticidal activity and shows higher effectiveness compared to N-methylcarbamates and organophosphorus compounds [3].

In acetone, in the presence of $(C_2H_5)_3N$, the reaction of CH_3–N=C=O with 3,5-$(C_2H_5)_2C_6H_3$–OH yields 3,5-$(C_2H_5)_2C_6H_3$–$OCONHCH_3$ with an 84.5% yield. The obtained product is an insecticide; for example, at a concentration of 2.5 mg/L, it shows effective action against Drosophila melanogaster [4].

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Both simple and targeted synthesis methods have been described. The reaction of R–N=C=O with 4-NO_2–C_6H_4OH (where R = naphthyl, phenyl, alkyl) produces R–NH–C(O)–O–C_6H_4–NO_2–p, which upon nitrosation gives R–N(NO)–C(O)–O–C_6H_4–NO_2–p with an 88% yield.

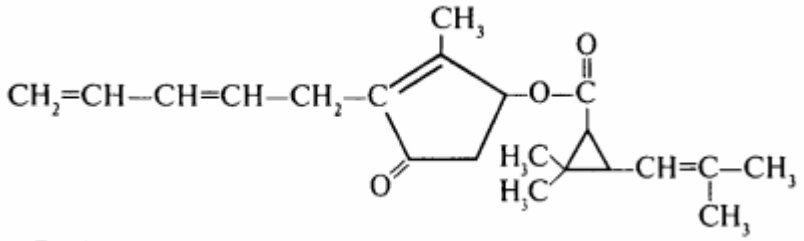
The pesticidal activity of aryl-N-alkylcarbamates depends on the nature and position of substituents in the benzene ring. A total of 45 compounds were synthesized and biologically tested, in which substituents such as R–OCO or R–OC(O)–NH (where R = alkyl, aryl, –N=CZ (Z = alkyl, aryl)) were introduced into the ortho-position of the benzene ring. A compound was synthesized from the reaction of 2-aminophenol–Cl–C(O)OR with CH_3N=C=O.

A compound with the formula 3-(2-Cl-4-$CF_3C_6H_3O$)$C_6H_4OCONHR$ (where R = H, alkyl, aryl, halophenyl) was obtained with a 57% yield by the interaction of 3-(2-chloro-4-trifluoromethylphenoxy)phenol with CH_3–N=C=O. The reaction products exhibit herbicidal activity when applied both before and after emergence against barnyard grass and broadleaf weeds.

N-arylthiocarbamates of the general formula $X_nYC_6H_{4-n}NHCOSR$ (R = CH_3, C_2H_5, cycloalkyl; X = halogen; Y = alkyl) [5] are synthesized via the reaction of $X_nYC_6H_4N$=C=O with R–SH in inert solvents in the presence of tertiary amines at temperatures ranging from –30 to 150°C, with a yield of about 64%. Application at a rate of 0.5–1 kg effectively eliminates many weeds without damaging crops such as peanut and wheat.

In recent years, preparations belonging to the pyrethrin class have gained significant importance among contact insecticides.

Pyrethrins are natural insecticides obtained from chrysanthemum plants and represent the active components of pyrethrum. Among pyrethrins, the most toxic compound for harmful insects possesses the following structure:



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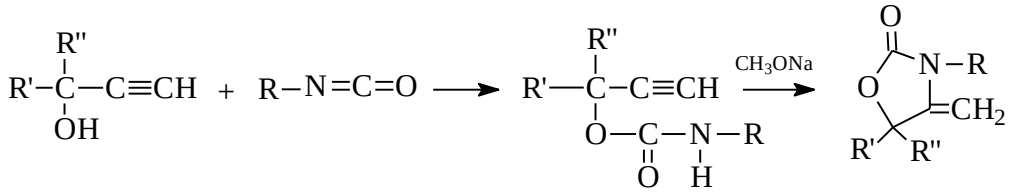
This compound is an ester formed from cyclic ketospirit pyrazolone and chrysanthemic acid. Pyrethroids are effective against pests and do not persist in the environment. Therefore, synthetic pyrethroids are currently being developed; however, they are relatively expensive.

British scientists [8] have developed a rapid and convenient method for the synthesis of carbamate insecticides, including methiocarb (I), carbaryl (II), and others, using N-bromosuccinimide as a reagent.

In the reaction of alkyl- or aryl-substituted propargyl alcohols with isocyanates (R–N=C=O), a single product, 2-methylene-dioxazolidine, is obtained. Previously, this compound had been incorrectly assigned the structure of 2-keto-1,3-oxazine.



In this work, the product yield was not specified.

Conclusion

At present, carbamates and their derivatives are considered highly reactive synthons in the field of organic synthesis of biologically active compounds. Numerous patents, articles, and monographs have been published on carbamate chemistry and their chemical properties, as well as on the pesticidal, herbicidal, fungicidal, insecticidal, nematicidal, acaricidal, and bactericidal activities of carbamate and bis-carbamate derivatives in agriculture. Scientists such as A.G. Maxsumov, N. Madixanov, U.A. Baltaboyev, M.A. Atakhodjayeva, N.A. Avinov, U. Tadjibayev, M.A. Talipova, A.D. Zakirov, U.B. Jo‘rayev, U.A. Aripov, O.V. Afanasyeva, Kh.U. Usmanov, Z.G. Haydarova, B.S. Sulaymanov, M.S. Xatamova, and others have been conducting research in this field [9–11].

Moreover, the synthesized compounds have significant advantages compared to other organic synthesis products, since the synthesis of carbamate derivatives does not produce gaseous or solid waste. Therefore, the developed waste-free technology for obtaining bis-carbamate derivatives is of great importance in organic synthesis due to its one-step process, economic efficiency, absence of waste, short reaction time, and high yield at room temperature.

It is known that theoretical studies of carbamate derivatives have revealed compounds with various types of biological activity, including herbicides, plant growth stimulators (biostimulants), defoliants, pesticides, fungicides, and pharmacologically active substances. Among bis-carbamate derivatives, hexamethylene bis[(alkyl)carbamates] have shown biostimulant activity. Studies of synthesized compounds have demonstrated positive results on widely cultivated agricultural crops such as cucumber, tomato, and cotton.

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