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Absorption of Preparations for the Protection of Wood by the Natural Sorbents with Different Degree of Fragmentation

Abstract

The growing demand for the impregnated wood products increases the production of wood preservatives, which can more likely be released into the environment. The vast majority of wood preservatives are the poisonous substances for the living organisms. Due to their properties, these measures may pose a threat to the environment and human health in the event of uncontrolled release. Their entry into the environment may take place at the stage of production, storage, transport or during various technological processes related to the wood processing. Threats associated with their uncontrolled release must be removed by the Fire Service specialized units of chemical and ecological rescue. The aim of the research was to analyze the impact of the degree of fragmentation of selected natural sorbents on the sorption of wood preservatives. A sorbent with a smaller grain size showed better sorption properties compared to the same sorbent with the larger grains due to the fact that it absorbed a larger total surface.

Key words: absorptive capacity of disintegrated sorbents, wood preservatives

Wchłanianie preparatów do ochrony drewna przez sorbenty naturalne o różnym stopniu rozdrobnienia

Abstrakt

Rosnące zapotrzebowanie na impregnowane wyroby z drewna powoduje wzrost produkcji środków ochrony drewna, co wiąże się z większym prawdopodobieństwem wystąpienia możliwości uwolnienia tych środków do środowiska. Zdecydowana większość środków przeznaczonych do ochrony drewna są to substancje trujące dla organizmów żywych. Z uwagi na swoje

właściwości środki te, w przypadku niekontrolowanego uwolnienia, mogą stwarzać zagrożenie zarówno dla środowiska, jak i dla zdrowia człowieka. Przedostanie się ich do środowiska może nastąpić na etapie produkcji, magazynowania, transportu lub w czasie trwania różnych procesów technologicznych związanych z obróbką drewna. Zagrożenia związane z ich niekontrolowanym uwolnieniem muszą być usuwane przez specjalistyczne jednostki ratownictwa chemicznego i ekologicznego PSP. Celem badań była analiza wpływu stopnia rozdrobnienia wybranych sorbentów naturalnych na sorpcję środków ochrony drewna. Sorbent o mniejszym rozmiarze ziaren wykazywał lepsze właściwości sorpcyjne w porównaniu do tego samego sorbentu o większych ziarnach z uwagi na to, że chłonił większą powierzchnią całkowitą.

Słowa kluczowe: chłonność sorbentów rozdrobnionych, środki ochrony drewna

Introduction

The possibility of using wood protection measures applies to every branch of the industry related to wood processing, such as construction, furniture but also the shipbuilding industry [4, 12]. Depending on the purpose of the wood, the protective substances can act: fungicidal, anti-corrosive or fire-retardant. Substances intended for the wood protection are divided into: biocides produced on the basis of pesticides, combating factors responsible for the biocorrosion of wood, hydrophobizing agents, reducing the possibility of water absorption and causing less favorable conditions for the development of fungi and bacteria, wood preservatives against ultraviolet radiation agents reducing the flammable properties of wood [1, 9]. Depending on the state of aggregation, the wood preservatives are divided into gaseous, liquid and solid substances [3, 8]. In order to investigate the sorption properties of the natural sorbents depending on the degree of their fragmentation, the research focused on the liquid substances [2]. However, in addition to ready-made chemicals in the liquid state, the solid materials are also used to prepare an impregnation solution, which includes the salt impregnates [6, 8]. The salt impregnates are prepared as mixtures of salts in the form of aqueous solutions.

Depending on the solvent used, they have properties that ensure swelling and shrinkage of the protected wood. These impregnates, depending on the composition, have different properties. The arsenic compounds as a protective factor are the salts of arsenic acid such as disodium diarsenide, disodium hydrogen arsenide, arsenic pentoxide and arsenic trioxide. These compounds are characterized by very high

toxicity and with the exception of arsenic trioxide, they dissolve well in water. The next are boron compounds, of which orthoboric acid and sodium tetraborate are used to protect wood. These compounds are characterized by low toxicity in relation to humans, while they kill fungi and insects. They also reduce the flammability of wood. They dissolve in water and due to the fact that they easily leach out of the material under the influence of water, it is recommended to use them only in places protected against rain. Next, there come the benzoates and salicylates possessing the bactericidal and fungicidal properties. They are not poisonous for humans and some of them have been used in the food preservation (sodium benzoate) [14]. However, the salicylic acid and benzoic acid are used to protect the wood. The next are chromium compounds used with the other salts due to their low properties for combating fungi and insects. Chrome has the properties for fixation in the wood structure through the reduction of hexavalent chromium to trivalent chromium. In this way it creates compounds that are sparingly soluble in water. Taking into account the carcinogenic properties of these compounds, their use has been severely limited, and their production in Poland is possible only with the consent of local Sanitary Department. Zinc compounds are also used in the form of zinc sulphate and zinc chloride, which dissolve well in water. Others are phosphorus compounds used because of their properties to reduce the flammability of wood. They do not have fungicidal or insecticidal properties. These compounds disintegrate into the ammonia and orthophosphoric acid under the fire conditions. Ammonia evaporates, dilutes fire gases and limits the access of oxygen to the combusted material, while the orthophosphoric acid is involved in the process of carbonizing wood, which limits the heating of the internal layers of the material. Another is the urea, which is soluble in water. Under the influence of high temperature (120–130°C), it decomposes into carbon dioxide and ammonia, which causes a reduction in the flammability of the material [7, 13].

The next group is the oil impregnates produced by the treatment of hard and brown coal and crude oil. They have water-repellent properties and easily penetrate its structure provided that the wood is dry. An undesirable property of these agents is increasing the combustibility of wood. In comparison to salt impregnates, they maintain their fungicidal and bactericidal properties much shorter. After the use of the oil impregnates, the volatile toxic substances are released, which have an adverse effect on the environment. The most commonly used oil is creosote oil, appearing in the form of a dark brown liquid with an unpleasant, characteristic odor. Due to the fact that the durability of the wood secured with this agent in contact with the soil

increases three times, and in some cases even ten times, it is often used for securing railway sleepers [9, 12].

In order to increase the bactericidal and fungicidal properties, the chlorinated hydrocarbons, naphthenate or organotin compounds are commonly added to the oil. Naphthenates and organotin compounds are: tributyltin naphthenate, copper naphthenate and tin naphthenate. A substance with the strong fungicidal properties and insecticides is tributyltin naphthenate. The triazole derivatives are strong fungicides, but they are characterized by the low toxicity in relation to warm-blooded organisms. The triazole derivatives such as tebuconazole and propiconazole used in concentrations of 0.6–1.5% are not dangerous for humans.

Carbamates are insecticides. Their action consists in blocking the activity of choline esterase. For the warm-blooded organisms they are low to medium toxicological risk [3, 7]. Decorative and protective preparations most often contain in their composition the solvents, synthetic resins, biocides and pigments. They are designed to give the wood surface the hydrophobizing properties, while maintaining gas exchange with the surrounding deeper layers of wood. These preparations also improve the aesthetics of wood [5, 10].

The fire protection coatings contain: the synthetic resins, chloroparaffins, petroleum solvents, anti-pyrimines as well as the biocides and pigments. These compounds undergo charring under the fire conditions. The resulting coal foams under the influence of water vapor, create a coating that protects deeper layers of wood against the spread of fire [11].

The impact of the wood protection measures on the environment and man

Substances used for the pressure and immersion impregnation such as: aliphatic amines, alcohol derivatives, copper compounds, propiconazole, boric acid are harmful to the aquatic organisms, which in the case of large emissions causes long-term damage to the aquatic environment. Oil preparations that give the wood hydrophobic properties include, among others, petroleum hydrocarbons that can penetrate into aquatic organisms and limit gas exchange and harm the photosynthesis process. The protective wood products also pose a risk to the soil environment. The conducted research has shown the release of copper and chromium ions into the soil environment [12].

The action of these substances on the human body can be acute or chronic. The most common effects include the irritation of skin, mucous membrane or conjunctiva

that is caused by the fumes of these substances. Roads that can be absorbed by the harmful substances contained in wood preservatives are: respiratory system, skin, gastrointestinal tract or through the contact with eyes. The inhalation is usually the most important way that solvents contained in the wood preservatives penetrate into the body. The fastest absorption takes place in the alveoli, the surface of which is almost 80% of the absorption area of the entire respiratory system. Absorption of the substances through the skin takes place by means of diffusion through the successive layers of the skin, and the moisture of the human body and sweating intensify their penetration. Exposing the organism to the harmful effects of a substance by swallowing it most often occurs after moving to the mouth from the hand, or together with food or drinks. Symptoms of poisoning include drowsiness, headaches, feeling of exhaustion, vomiting, loss of coordination, loss of consciousness or even death. The prolonged exposure to organic solvents may cause damage to internal organs, such as the liver and kidneys. The workers who produce these products and those responsible for storing waste generated during the production process are particularly exposed [5].

Research methodology and test stand

The object of the research was two natural sorbents (peat and diatomaceous earth) in two different degrees of fragmentation. The diatomaceous earth was tested in the following fractions: – 0.5 μm – 100 μm (dust) and – 0.5 mm – 1 mm. In contrast, the peat in the following fractions: 0 mm – 2 mm and 2 mm – 6 mm.

The sorption properties of the indicated sorbents were tested during the absorption of two different sorbates:

The sorbate 1 is an impregnation that protects wood against the effects of insects and fungi that causes a deep decomposition of wood. The following hazard information is on the sorbate packaging: H 315 – irritates the skin, H 317 – may cause allergic skin reactions, H 318 – causes serious eye damage, H 314 – harmful to water organisms, causing long-lasting effects.

The sorbate 2 is an impregnating agent that gives wood its hydrophobic properties, which protects it against weathering. It is a flammable liquid that after transfer into the human body through the digestive or respiratory tract is a direct threat to human life [1, 4].

During the test, the following protective measures were applied: the lab coat, the gloves and the protective goggles, as well as the mask protecting the respiratory tract.

The laboratory stand on which the examination was performed was equipped with a fume hood.

There were no outsiders nearby. Such safeguards were adequate to the level of risk that occurred during the test. The recommendations on the sorbates on packaging were followed.

Figure 1 shows the diagram of the research position.

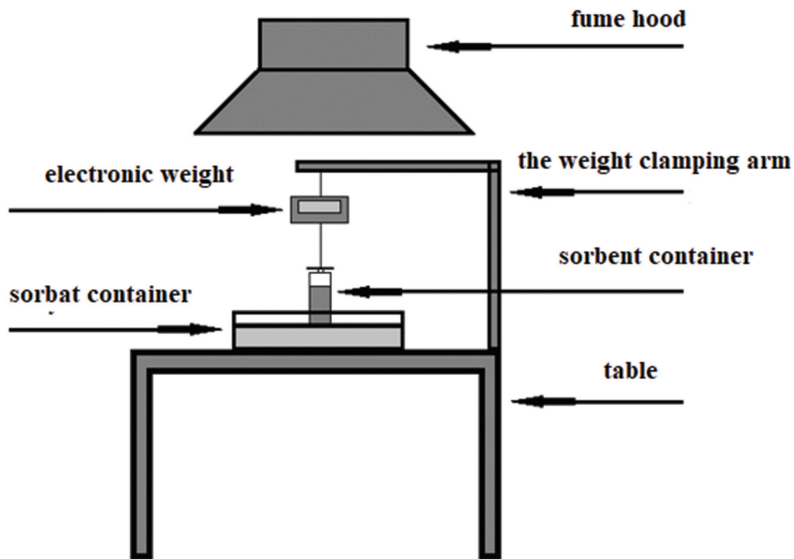


Fig. 1. Scheme of the research position

Source: own study

50 cm³ of sorbent was placed into the syringe, weighed and its weight recorded. The electronic balance was tared and the sorbate poured into the container to make the contact with the sorbent 1–2 mm. The values from the electronic balance were read every 10 seconds with an accuracy of 0.01g and recorded. This operation was repeated until the same value was indicated three times by the weight. The test was repeated for each sorbent and sorbate.

Findings

Figures 2 and 3 present a comparison of sorption properties of individual sorbent fractions with absorption of the sorbate 1.

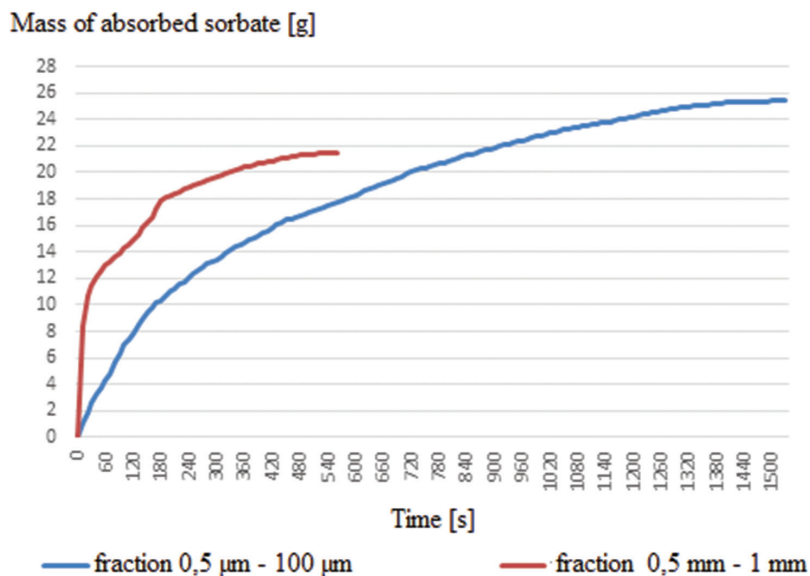


Fig. 2. Comparison of the sorptive properties of the diatomaceous earth with the fraction of 0.5 µm – 100 µm and 0.5 mm – 1 mm – sorbate 1

Source: own study

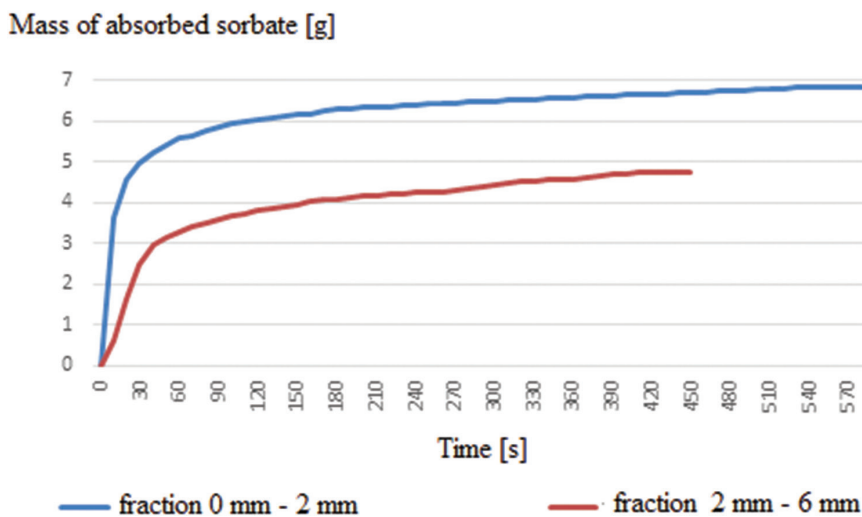


Fig. 3. Comparison of the sorptive properties of peat with the fraction of 0 mm – 2 mm and 2 mm – 6 mm – sorbate 1

Source: own study

Figures 4 and 5 present a comparison of the sorption properties of the individual sorbent fractions with the absorption of sorbate 2.

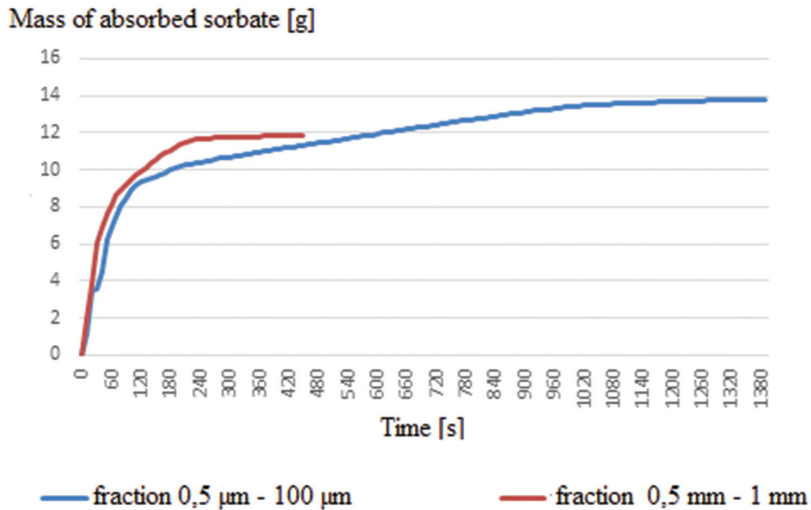


Fig. 4. Comparison of the sorptive properties of the diatomaceous earth with the fraction of 0,5 μm – 100 μm and 0,5 mm – 1 mm – sorbate 2

Source: own study

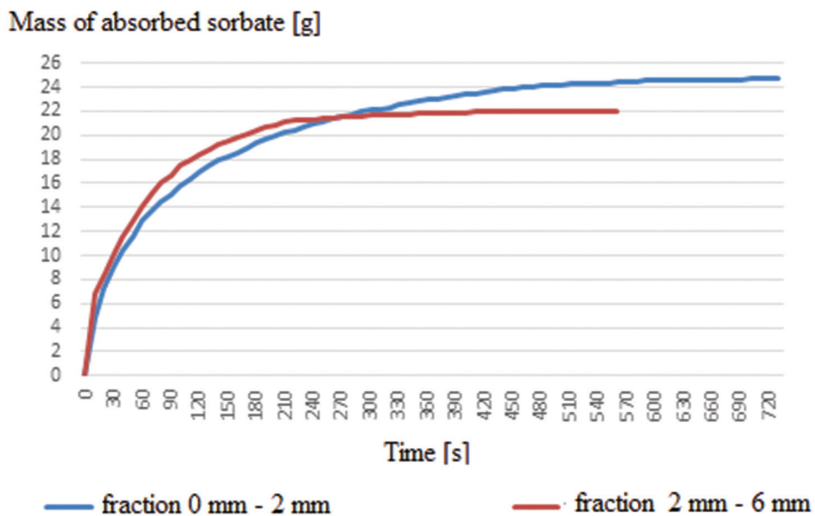


Fig. 5. Comparison of the sorptive properties of peat with the fraction of 0 mm – 2 mm and 2 mm – 6 mm – sorbate 2

Source: own study

The research shows that the sorption coefficient increases with the degree of the sorbent fragmentation. The smaller the sorbent grains, the larger the sorption coefficient – Figures 6 and 7.

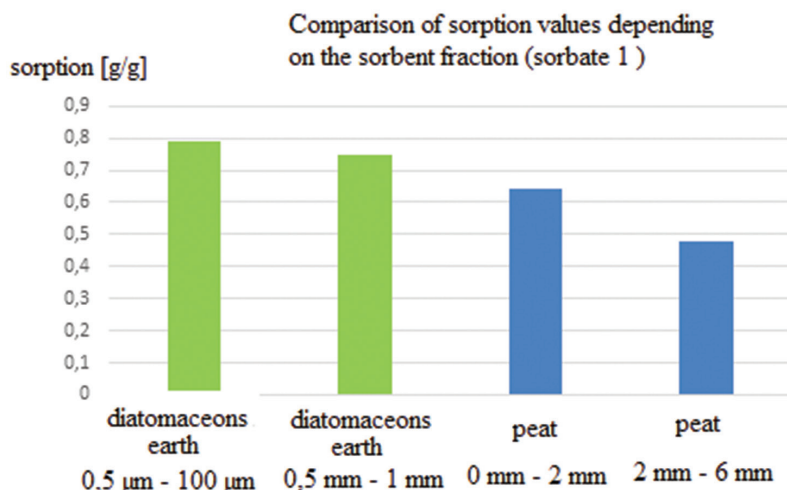


Fig. 6. Comparison of the sorption values depending on the sorbent fraction (sorbate 1)

Source: own study

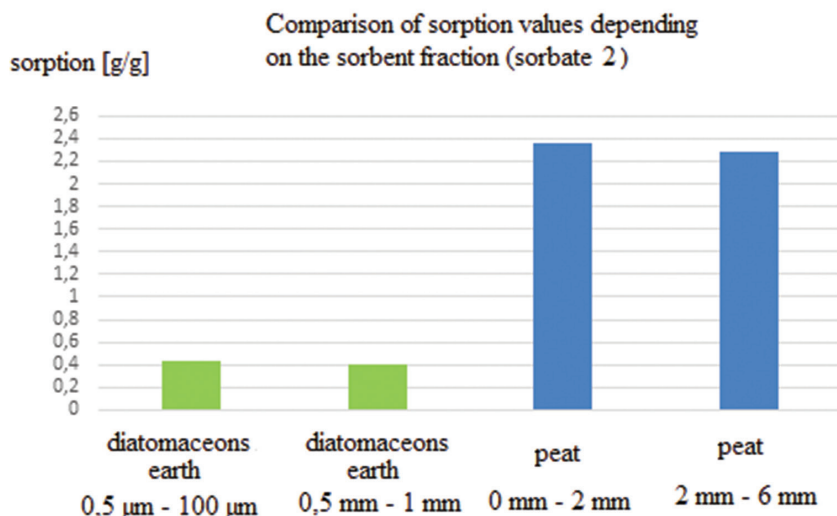


Fig. 7. Comparison of the sorption values depending on the sorbent fraction (sorbate 2)

Source: own study

Summary and Conclusions

On the basis of the conducted tests, it was found that 50 cm³ of diatomaceous earth from 0.5 μm – 100 μm fraction, absorbed more sorbate (both during the tests using sorbate 1 and sorbate 2 than the same volume of diatomaceous earth from the 0.5 mm – 1 mm fraction). The sorption process with a smaller grain size sorbent lasted longer. The fraction of 0.5 μm – 100 μm absorbed 25.41 g of sorbate 1 during 1530 s and 13.82 g of sorbate 2 in 1390 s, while grain size 0.5 mm – 1 mm after 560 s absorbed sorbate 1 and after 450 s in the case of the sorbate 2 study, absorbing respectively at this time 21.44 g and 11.85 g of individual sorbates. In each of the cases studied for diatomaceous earth sorption of the absorbed substance in the initial phase of the process was faster for the larger fraction of the sorbent tested, however, the process was slower, compared to diatomaceous earth with a fraction of 0.5 mm – 1 mm. The sorbent fractions analyzed absorbed more sorbate 1.

In the case of studies using peat, it was found that similarly as in the previous case, a smaller fraction, i.e. 0 mm – 2 mm, absorbed more sorbate and needed more time to complete the sorption process. When absorbed by peat the sorbate 1 the sorption phenomenon occurred from the beginning faster for a sorbent containing smaller size grains. The sorbate 2 was absorbed by peat at a similar rate by both studied fractions.

The harmful ingredients of the wood preservatives accumulated in the environment are hazardous waste and may pose a risk to people. Due to the properties of wood preservatives, when using them, the appropriate personal protective equipment should be used.

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