



Study of the Possible Negative Influence of a New Biopolymer Containing Tetraethoxysilane on a Living System in an Experiment

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ABSTRACT

At the present stage, the analysis of the data available in the literature has revealed the negative impact of some building boards based on phenol-formaldehyde resins on human health. In this regard, there is a need to create environmentally friendly, health-safe composite materials. The number of studies devoted to the development of new environmentally friendly adhesive compositions and their use in wood composites has also increased.

Based on the above, the aim of the presented work was to identify the possible negative impact of a composite based on Yucca Gloria modified with Tetraethoxysilane on the morphofunctional activity of various tissues of adult white mice.

Studies have shown that a composite based on Yucca Gloria modified with Tetraethoxysilane does not cause changes in the total number of leukocytes in the peripheral blood of adult white mice. Also, no negative effect of this composite on the histoarchitecture of various tissues (liver, brain) of adult white mice was detected.

The obtained results show that the composite based on Yucca Gloria modified with Tetraethoxysilane does not cause changes in the morphofunctional activity of various organs of white mice, which indicates the absence of the ability of this composite to exert a cytotoxic effect on a living organism.

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Introduction

At this time, the problem of developing biomaterials based on wood, thermoplastic polymer matrices reinforced with fillers is becoming especially relevant. Increased interest in these biomaterials is due to their environmental friendliness and high economic efficiency. At present, special importance is attached to the production of wood-polymer composites (WPC), which are widely in demand in industry and construction. The creation of such composites, characterized by ease of processing, environmental friendliness and low cost, has become in demand. Environmentally friendly and renewable biopolymers are used in almost all sectors of the national economy. In this regard, researchers have a growing interest in bioorganic composite materials [1-4].

Today, this problem is relevant in almost all countries of the world. Therefore, in a number of countries, for example, in the USA, from 2013 it is planned to introduce new standards for formaldehyde emissions from materials obtained using phenol-formaldehyde resins. According to these standards, established by the World Health Organization, formaldehyde resins must be replaced with environmentally friendly binders [5].

In this regard, a new environmentally friendly and safe composite material is of interest, in which silylated styrene is used as a binder [6,7]. Studies conducted on experimental animals (adult white mice) have shown that a wood composite in which silylated styrene is used to glue wood shavings does not have a negative effect on the morphofunctional activity of various tissues of white mice. Moreover, it was found that sheets of composite material based on styrene, silylated vinyltriethoxysilane, and hay do not have the ability to have a negative effect on the histoarchitecture and proliferative activity of various tissues in adult mice [8,9].

Over the past 2-3 years, a bioorganic composite material (binder - polypropylene powder, modifier - liquid tetraethoxysilane) has also been developed based on the leaves of Yucca Gloria - a woody plant of the lily family [10]. The mechanical properties of the obtained composites were improved by modification. The microstructure and chemical composition of the bioorganic composite materials were studied using optical biological microscopy and infrared spectroscopy (FTIR). Therefore, we found it interesting to evaluate the effect of the obtained bioorganic composite on experimental animals.

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Based on the above, the aim of the presented work was to study the possible negative impact of a composite based on Yucca Gloria modified with Tetraethoxysilane on the morphofunctional activity of the white adult mice various tissues.

Materials and Methods

The object of the study was 50 white adult mice weighing 25–30 g. Various tissues of adult mice (blood, liver, brain) were used as the test material. To assess the effect of the specified composite, the animals were divided into 2 groups: the control group - intact animals; the experimental group - animals kept in cages covered with the studied composite for 40 days. After 40 days, tissue samples were taken under diethyl ether anesthesia.

Liver and brain was fixed in buffered formalin 4% solution pH 7.2–7.4 for 2 days. After fixation, the tissue were processed and embedded into paraffin blocks, sectioned by Leica microtome (thickness of sections -5 μm) and stained using standard protocol of hematoxylin and eosin (H&E) [11]. Tissue samples were studied under the light microscope (Zeiss Primo Star, Germany). A Goryaev chamber was used to assess the total number of leukocytes in the blood.

Results and Discussion

Figure 1 shows a graph of changes in the total number of leukocytes in the peripheral blood of animals in the control and experimental groups. Figure 1 clearly shows that the composite based on Yucca Gloria modified with Tetraethoxysilane does not cause changes in the total number of leukocytes in the blood of white mice over 40 days.

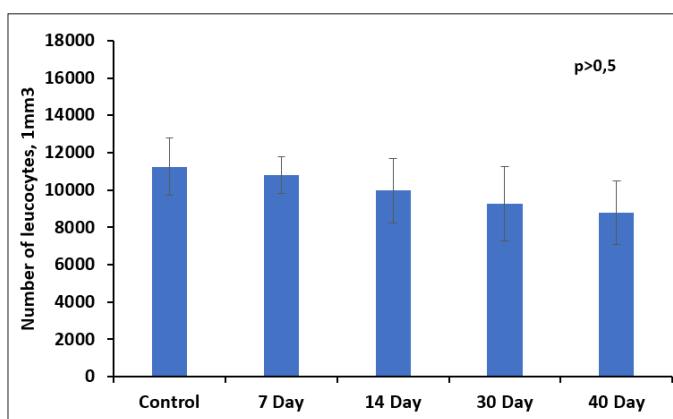


Figure 1: Effect of Composite Based on Yucca Gloria Modified with Tetraethoxysilane on total Leukocyte Count in Peripheral Blood of Adult Mice

In parallel, the Histoarchitecture of the Studied Tissues of Animals from the Control and Experimental Groups was Studied.

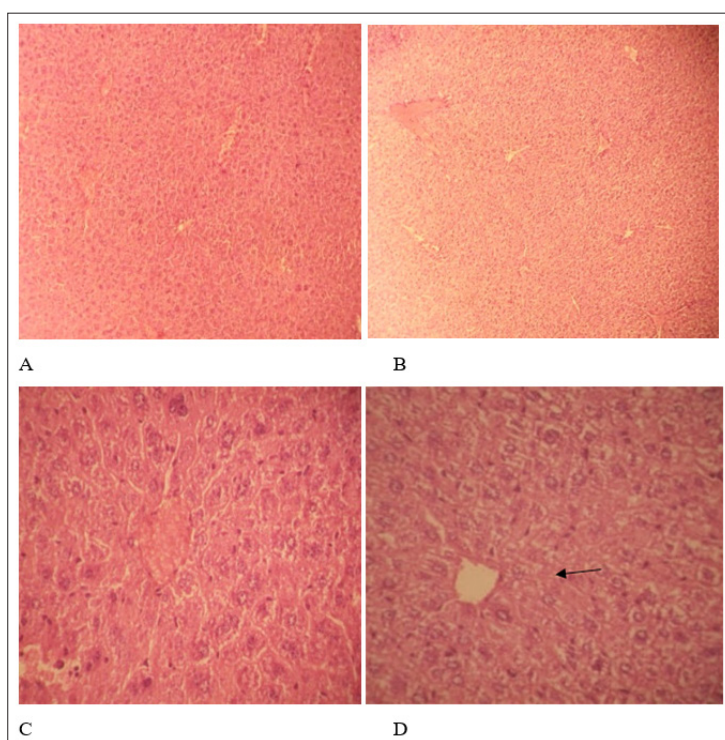


Figure 2: Liver Tissue of Adult White Mice: of the Control (A, C) and Experimental Groups (B, D), Arrow - Central Vein (D) (A, B -100X, C, D - 400X, H&E)

Figure 2 shows the histoarchitecture of the liver of animals of both groups. Micrographs (2A and 2C) clearly show the tissue structure characteristic of the intact liver. In particular, large binuclear hepatocytes are clearly visible in the bundles directed radially to the central vein, sinusoidal capillaries and the Disse space are visible between the bundles. No infiltration is observed in the field of vision (2A and 2C). Similar results were obtained when evaluating micrographs of the liver tissue of animals in the experimental group (2B and 2D). It is evident from the figure that, as in the control animals, no structural changes caused by the effect of the wood composite based on Yucca Gloria modified with Tetraethoxysilane were detected in the liver of animals in the experimental group (2B and 2D).

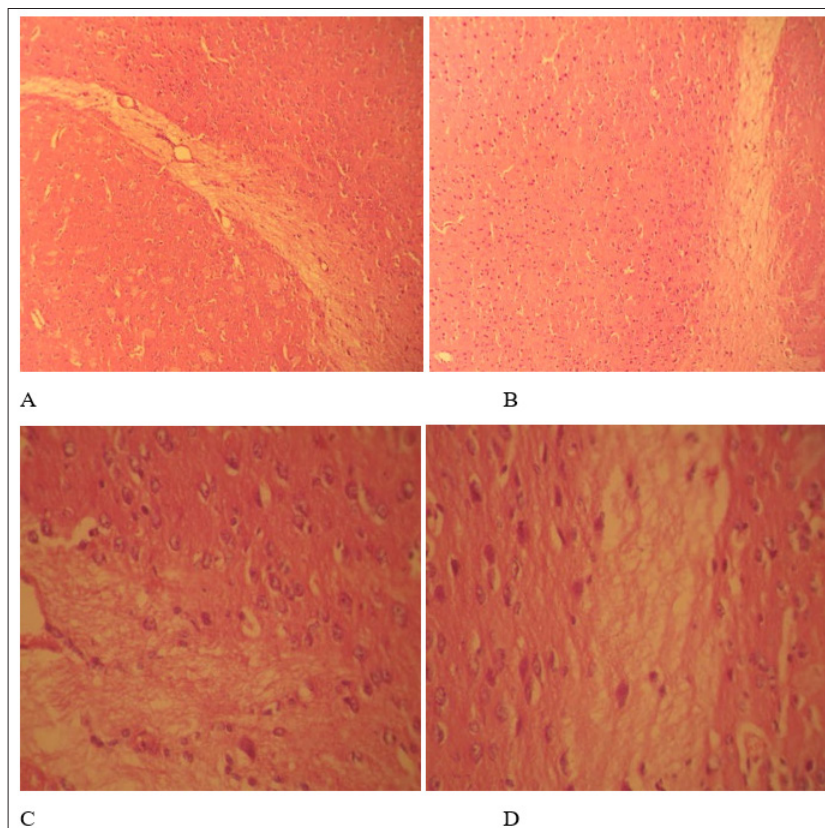


Figure 3: Brain Tissues of Adult White Mice of The Control (A, C) and Experimental Groups (B, D), Respectively (A, B - 10X, C, D - 40X, H&E)

In parallel, the effect of this composite on changes in the histoarchitecture of brain tissue in control and experimental groups of animals was studied. The study showed that the cytoarchitecture of the cerebral cortex of both the control and experimental groups of animals was preserved. In particular, the cellular structure is preserved, clearly defined large nuclei, as well as the cytoarchitecture of the layers, were not damaged (Fig. 3a ,3c and 3b,3d). Similar results were obtained by us in the case of a new wood composite containing hay, styrol and triethoxysilyl (4-vinilfen methyl) silane [12].

Conclusion

Analysis of the obtained results shows that the bioorganic composite material based on Yucca Gloria leaves (binder – polypropylene powder and modifier – liquid tetraethoxysilane) is an environmentally friendly polymer composite that does not have a cytotoxic effect on various tissues of adult white mice.

References

- [1] Islam MR, Beg MDH, Mina MF. Fibre surface modifications through different treatments with the help of design expert software for natural fibre-based composites. *J. of Composite Materials*. 2013; 48: 1-13.
- [2] Lebedev V, Miroshnichenko D, Pyshyev S, Kohut A. Study of hybrid humic acids modification of environmentally safe biodegradable films based on hydroxypropyl methyl

cellulose. *J. Chem. & Chem. Technol*. 2023; 17: 357-364.

- [3] Mukbaniani O, Tatrishvili T, Kvnikadze N, Makharadze T, Petriashvili G. Bamboo-containing composites with environmentally friendly binders. *J. Chemistry & Chemical Technology*. 2023; 17: 807-819.
- [4] Jadhav A, Thangaraj Mohanraj G, Gokarn A, Mayadevi S. Synthesis of biomass waste derived activated carbon-NBR composites for automobile application. *J. Chemistry & Chemical Technology*. 2018; 12: 135-278.
- [5] <https://www.cancer.gov/about-cancer/causesprevention/risk/substances/formaldehyde/formaldehyde-fact-sheet>.
- [6] Mukbaniani O, Aneli J, Buzaladze G, Markarashvili E, Tatrishvili T. Composites on the basis of straw whit some organic and inorganic binders. *Oxidation Communications*. 2016; 39: 2763-2777.
- [7] Goliadze M, Bedineishvili N, Berulava M, Dzidziguri D. Comparative study on impact of the new compositions on the Histoarchitectonics of the white mice organs. 6th International Symposium on Polymers and Advanced Materials. Batumi 2019; [https://www.icsp6.tsu.ge/data/file_db/icsp6/SYMPOSIUM_2019_abstract\(1\).pdf](https://www.icsp6.tsu.ge/data/file_db/icsp6/SYMPOSIUM_2019_abstract(1).pdf).
- [8] Goliadze M, Berulava M, Razmazashvili M, Dzidziguri D. The wood compositions, having different technical features and

- their influence on the biological systems. Fifth Caucasian International Symposium on polymers and Advanced Materials. Tbilisi 2017.
- [9] Goliadze M, Bedineishvili N, Berulava M, Markarashvili E, Mukbaniani O, et al. New wood composites influence of the morpho-fuctional activity of the different tissues of adult and old white mice; PolyChar 26 World Forum on Advanced Material. 2019.
- [10] Mtchedlishvili M, Tabatadze L, Gventsadze D, Lezhava T, Gventsadze L, et al. Technological Aspects of Biopolymers Based on Yucca Gloriosa Fiber. Biopolymeric Materials BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES. 2024.
- [11] Cardiff RD, Miller CH, Munn RJ. Manual hematoxylin and eosin staining of mouse tissue sections. Cold Spring Harbor Protocols. 2014; 6: 655-658.
- [12] Tavdishvili E, Markharashvili E, Berulava M, Nakhutsrishvili G, Londaridze L, et al. Study of possible negative impact of new composite containing hay, styrol and triethoxsilyl (4-vinilfenethyl) sylane on a living system. Chemistry & Chemical Technology XI international scientific-technical conference «Advance in Petroleum and Gas Industry and Petrochemistry» Proceedings. 2022.