Prospects of Applying of Ingo-2 Nanostructured Carbon Sorbent in Cases of Intoxication with Heavy Metals

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Abstract

The active centers of the carbonization of carbon sorbents from vegetable raw materials (rice husks) were altered to purposefully modify the surface of the Ingo-2 nanostructured carbon sorbent. The study revealed a corrective effect of Ingo-2 on the organism of animals experiencing in chronic intoxication with heavy metals. Experimentally, morphological, digital and mathematical assessment of the condition of the mucous membrane of the digestive tract laboratory animals (white rats) in vivo revealed the influence of Ingo-2 on the deposition and the excretion of Cu^{++}, Pb^{++} ions. This was confirmed by the absence of morphological changes in the experimental animals when administered in the diet over 17 days, with 5–10 g sorbent Ingo-2 used for the neutralization of 10 mg $Pb(NO_3)_2$ and $Cu(NO_3)_2$, which represents approximately 0.1 LD50 (Lethal Dose). The methodology of the research established positive effects of these treatment and its quantitative characteristics were defined.

Introduction

The expediency of exploratory research is affected by the necessity of expanding the range of sorbents with more efficient properties. According to different estimates, from 40 to 70% of new drugs are created based on natural molecules or their synthetic analogues and derivatives. Thus, plant compounds may be developed into sorption biosystems with qualitatively new properties. From this point of view, the development of selective nano sorbents for medicine, which combines the properties of mineral matrix and carbon nanostructures is of special interest [1-6].

Carbonization was activated in vegetative raw material (rice husks) using the Ingo-2 nanostructured carbon sorbent. This sorbent has a nano-sized morphology and specific properties [7-10]. The aim of changing the active centers of carbonization of the carbon sorbent from vegetable raw materials to purposefully modify the surface of Ingo-2 was to give it hydrophilic-hydrophobic and hydrophilic properties. The study revealed the corrective effect Ingo-2 on the water – and electrolyte – secretory function of the kidneys in case of chronic intoxication with heavy metals.

These properties allow us to offer this material as a unique nanostructured sorbent to treat heavy metal toxicitys.

The first step in the creation of selective materials is the regulation of pore sizes of the sorption materials. This condition corresponds to the obtained Ingo-2 sorbent. Electron-microscopic study of the source and carbonated samples showed that by activation achieved a developed structure with a better surface area and density. The matrix had a stable, clear mesoporous and macroporous structure, with a high specific surface area of up to 300 m^2/g, preferential pore size of 10–100 nm, and high sorption activity.

Also important in the creation of selective sorbents is the chemical nature of the surface. The modification of well-organized nanostructures allowed us to obtain an efficient sorbent, that combined the properties of mineral matrix and carbon nanostructures, there by expanding the potential of the sorbent and allowing it to sorb not only hydrophilic molecules, but molecules with hydrophobic properties on its surface. Given the physico-chemical properties of these natural formations, their prospects for use in clinical practice are clear.

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In connection with this, the aim of the present research was to modify sorbents from vegetable raw materials (rice husks) and experimentally study the effects and pathophysiological mechanisms of influence Ingo-2 in rats.

Experimental

For the analysis of the carbohydrate composition of the gel, penetrating chromatography was used. Chromatograms were recorded on a ZHKH-1307 chromatograph using a refractmetric detector.

The sorption activity of Ingo-2 was studied using a Metrohm (Switzerland) device. Processing of the results was carried out using 757 VA VA Comp trace System.

The ultra structural organization was investigated using a Tesla BS-500 electron microscope.

The sorption properties Ingo-2 were assessed through changes in the morphological and hematological parameters in vivo.

The hematological, morphological, physiological, and behavioral test were processed by [11-15]. The experimental data were processed using the probabilistic methods of mathematical statistical dispersion and correlation analysis.

The objects of the study were adults white outbred male rats aged approximately 4 months in compliance with the chronobiological requirements. The body weight of the animals varied from 130 to 230 g according to age.

Results and Discussions

In accordance with the experimental three 3 groups of animals were formed. The concentration of substances used such that condition chronic, rather than acute poisoning was simulated. Access to water was free.

The biological control group received the normal fodder without impurities or concentrates (normal food diet), which allowed the normal values to be determined for experimental work. For every animal in groups II and III, 10 mg $Pb(NO_3)_2$ and $Cu(NO_3)_2$, which is approximately 0.1 LD50, was administered in 1 ml of distilled water. Experimental group III received approximately 5-10 mg Ingo-2 30-40 minutes before meals, this corresponds to the effective dose.

Protocol experiments in relation to the selection, content of animals and excretion was drafted in accordance with the principles of bioethics and the rules of laboratory practice.

Blood sample were collected in a sterile tube from the lower hollow vein after opening the middle section of the abdominal cavity. The blood was not fixed, and it was immediately sent for clinical analysis.

Table 1

Hematological, morphological, physiological and behavioral responses in the biological control, and groups II and III from day 2 to day 17

Parameters	Stages of the experiment					
	The group of biological control		II group		III group	
Hematologic test						
	2^{-nd} day	17^{-th} day	2^{-nd} day	17^{-th} day	2^{-nd} day	17^{-th} day
Leukocyte count, $109 \cdot l^{-1}$	11±1	11±1	15±1	8±1	10±1*	10±1
Hemoglobin, $g \cdot l^{-1}$	115±2	107±3	106±3	91±5	101±2	108±3
Erythrocytes, $1012 \cdot l^{-1}$	8±1	5±1	7±1	5±1	7±1	7±1
Morphological and physiological measurements						
Weight, g	205±10	228±12	204±2	212.2±3*	206±11	218±10
The frequency of respiratory movements per minute	134±3	142±4	126±2	138±8	132±2	146±2
The body temperature, °C	35±1	36±1*	36±1	37±1	35±1	36±1*
Behavioral test						
Test «OFF» - «open field»	53±8	34±7	49±2	20±5*	51±6*	27±2*
Test «ON» - «hanging»	22±3	10±1	21±2	12±2	22±3	10±1*

Changes in the hematological parameters, as well as the morphological, physiological and behavioral reactions of the animals in two from day 2 to day 17 after the start of the experiment were recorded.

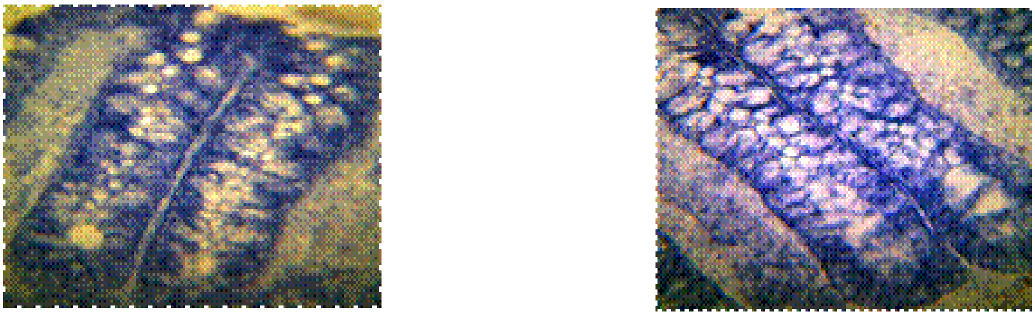
Thus, all the established indicators (red blood cells, respiration rate, body temperature and etc.) demonstrated that the toxicity rather was not observed in experimental animals in group III.

In terms of morphological, the animals group II showed deep and irreversible structural changes in the mucous membrane of the thin and thick intestines due to the use of copper nitrate and lead nitrate. The animals in pilot group III showed no morphological changes associated with the use of copper nitrate and lead nitrate in the complex with Ingo-2.

The test animals exhibited minor changes in the activity of some morphological-equivalents functional states, and in terms of age group (2 months), the control animals revealed the predominance of a relationship with weak and medium-strength; with age, the correlation dynamics changed direction and lost its force.

Analysis of morphological types of fat cells mucous membrane of the large intestine of control animals revealed the predominance of ungranular cells, which was due to the cytoplasts and specialized cells in all periods of observation.

Thus, with age, slight morpho-functional changes were observed in the mucosa of the large intestine, decreasing of some histological and enzymological indicators and increasing the number of mitotic cells and the total number of fat cells. Goblet cells in the epithelium of mucous membrane of the large intestine on the 2^{-nd} and 17^{-th} day of the experiment are shown in Figures 1-3. The morphological picture of the group III experimental animals was in fact not different from that of control animals.



a b

Fig. 1. Goblet cells in the epithelium of the mucous membrane in the large intestine of biological control group animals: a – 2^{-nd} day; b – 17^{-th} day.

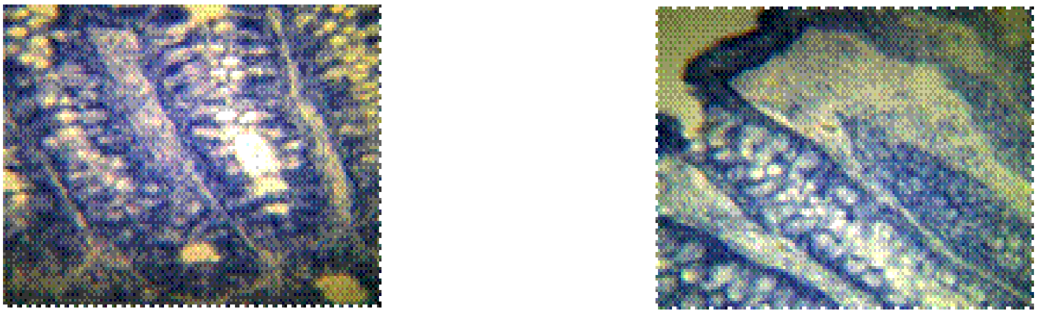


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Fig. 2. Goblet cells in the epithelium of the mucous membrane in the large intestine of group II animals: a – 2^{-nd} day; b – 17^{-th} day.

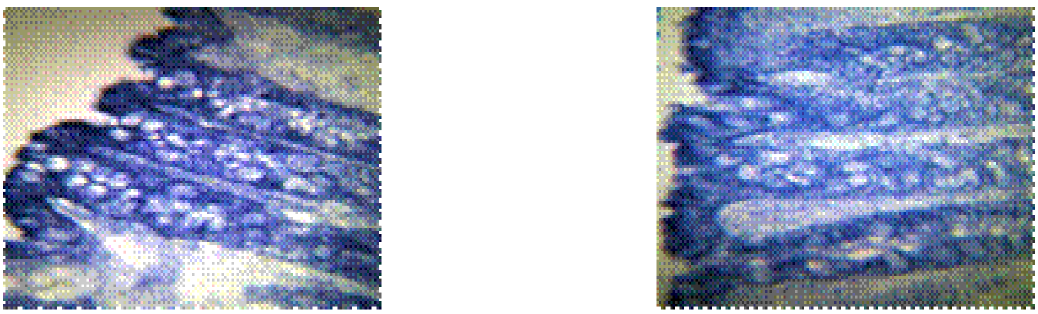

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Fig. 3. Goblet cells in the epithelium of the mucous membrane in the large intestine of group III animals: a – 2^{-nd} day; b – 17^{-th} day.

The analysis of the obtained data shows that, lead nitrate and copper nitrate together with the main food diets resulted in significant changes of hematological parameters of experimental animals (the leukocyte count increased to 15±19·109·l^{-1}, hemoglobin decreased to 91±5 g·l^{-1}, and red blood cells remained virtually normal - at 7±1·1012·l^{-1}. Morpho-physiological and behavioral indicators were as follows: weight decreased within the limits of variation of the norm, the rate of respiration reliably decreased n the body temperature rise. To evaluate changes in the animals of group II, the following criteria related to the processes of intoxication were used. Other criteria indirectly testified to processes of chronic intoxications of an organism with nitrates, copper, and lead.

In the large intestine of control animals, age-related decline was observed in the activity of alkaline phosphatase and glucose 6-phosphate dehydrogenase ($p<0.05$). Histological and chemical equivalents aerobic and anaerobic processes, succinate dehydrogenase and lactate dehydrogenase were showed the toxicity stress ($p<0.05$). The age dynamics of the number of mitotic cells in the epithelium of the crypts colon is characterized by an increase with a longer time of observation. In the stroma of the mucous membrane of the large intestine, control animals exhibited an increase in the total number of fat cells.

Thus, one can speak of disharmony in the metabolic processes of the thin and thick intestines of animals in experimental group II after 17 days. The animals in pilot group III did not show morphological changes associated with the use of copper nitrate and lead nitrate in the complex with food biosystems.

Conclusion

The studies confirmed the sorption properties of the studied Ingo-2 nanostructured carbon sorbent in relation to the Pb^{++} and Cu^{++} ions in vivo.

The obtained positive results allow a conclusion to be made about the effectiveness of the use of Ingo-2 sorbent, in efferent therapy.

The study reveled the corrective effect of Ingo-2 in animals experiencing chronic intoxication with heavy metals.

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