Сојуз на хемичарите и технолозите
на Македонија

Society of Chemists and Technologists
of Macedonia

15th Students' Congress of SCTM

BOOK OF ABSTRACTS

29th September - 1st October 2022
Institute of Chemistry
Skopje, N. Macedonia

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Dear students, colleagues and guests,

It my great honor and privilege to extend to you all a very warm welcome to the Students' Congress of the Society of Chemists and Technologists of Macedonia. This is our 15th students' congress so, for us, it is a cause for a small celebration. The first students' congress was in 1994 (the organizers were Orhideja Grupče, Vladimir Petruševski, Minjas Žugić). The SCTM has a long tradition of organizing chemistry conferences, dating back to 1970; next year we will have the 26th Congress of SCTM, traditionally held in Ohrid.

First, I would like to greet and thank the student participants – I believe for many of you this is the first time to take part in such an event and a good practice for international conferences we believe you will attend in the future. That is why we are having it in English. This year we have about 30 oral presentations, in other words a full two-day schedule.

I would also like to thank the lecturers who have accepted our invitation – this time we have five. We have one from the University of Belgrade and one from the University of Zagreb and I sincerely hope you will enjoy your stay here in Macedonia. The other three are from the University Goce Delčev in Štip, the Faculty of Technology and Metallurgy and the Institute of Chemistry.

I would like to express my special gratitude to our honorable guests:

- Prof. **Elizabeta Gjorgjievska**, our First Lady and good friend of our Society who has found the time in her busy schedule to attend this opening ceremony in support of the young researches presenting their research at this Congress.
- Prof. **Aleksandar Skeparovski**, the Dean of the Faculty of Natural Sciences and Mathematics. I would like to take this opportunity to thank him for all the support he is giving our Society, including the financial support.
- Academician **Gligor Jovanovski** who was a driving force behind the Students' Congresses and we are all indebted to him for this.

Finally yet importantly, I would like to thank the organizers for the time and energy they have dedicated to ensuring that this event is a success. President of the Scientific Committee Prof. **Nataša Ristovska**, the president of the Organizing Committee MSc **Pece Šerovski** as well as the members from the Faculty of Technology, Prof. **Biljana Angjuševa** and Prof. **Dafinka Stoevska Gogovska**.

I do hope you will have a fruitful and enjoyable exchange of ideas these two days at the Institute of Chemistry!

Prof. Zoran Zdravkovski, president
Society of Chemists and Technologists of Macedonia

PL-2

CHEMICAL AND ATMOSPHERIC PRESSURE PLASMA TREATMENTS, COST-EFFECTIVE WAYS FOR IMPROVING THE JUTE FABRIC PROPERTIES AND EXTENDING ITS LIFECYCLE

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The increased demand for cheap, biodegradable, renewable, and recyclable fibers with good electrical, thermal, sorption, and mechanical properties positioned jute in second place (after cotton) in the natural fiber world market. Multicellular jute fibers are recognized by their heterogeneous chemical composition which includes α-cellulose (58-63%), hemicelluloses (21-24%), lignin (11-12%), and some minor components (like fats, waxes, and pectin). The non-cellulosic components (especially hemicelluloses and lignin) negatively affect fibers' processing leading to limited application. However, cellulose and non-cellulosic components have excellent reactivity due to the presence of a high amount of functional groups (hydroxyl, carboxylic, phenolic, aldehyde), making jute fibers suitable candidates for a variety of chemical (such as alkali and oxidative), and physical modifications and adjustments in their structure and properties.

This paper summarizes the investigation focused on chemical and atmospheric pressure plasma treatments as fast and cost-effective methods for improving the jute sorption and electro-physical properties. Alkali modifications with sodium hydroxide lead to selective hemicellulose removal, increased the content of cellulose exposed on the fiber surface, decreased the crystallinity index, and contributed to elementary fiber liberation. Modifications using $> 10\%$ NaOH (so-called mercerization) change the structure of the native cellulose I to cellulose II and increase the number of possible reactive sites. On the other hand, the sodium chlorite modifications are used to selectively remove lignin, which is followed by simultaneous oxidation of fiber carbonyl into the corresponding carboxyl groups. Furthermore, periodate oxidation lead to the conversion of cellulose hydroxyl groups on C2 and C3 atoms to aldehydes, wherein the ring cleavage occurred and 2,3-dialdehyde cellulose was formed.

Nevertheless, the alterations of molecular-, fine, and microstructure, these chemical modifications also homogenize jute fiber structure, and thus, provide unique sorption and electro-physical properties. Some of the biggest benefits of the jute fibers' alkali and oxidative modifications are improved accessibility of the cell wall components to water vapor, and the total water holding capacity, which lead to the increase in the moisture sorption, water retention power, and degree of fiber swelling. The jute electro-physical properties such as dielectric loss tangent, AC specific electrical conductivity, effective relative dielectric permeability, and volume electrical resistivity are very sensitive to fibers' chemical composition, crystallinity, and their ability for moisture sorption. More precisely, alkali modifications under mild conditions lead to a decrease in the volume electrical resistivity, while the resistivity of mercerized jute is mostly dictated by the presence of cellulose II polymorph as well as pronounced fiber liberation and fabric crimp. The overall improved AC specific electrical conductivity of the jute fabrics with lower hemicellulose content is the sum of three contributors: moisture sorption, crystallinity index, and hemicellulose content. In the case of jute fabrics with lower lignin content, the moisture sorption and crystallinity index significantly influences the AC specific electrical conductivity only at a lower relative humidity (30% RH), while, at a higher relative humidity (80% RH), the moisture sorption and bulk-free water have a higher influence. The obtained increase of the effective relative dielectric permeability after the alkali and oxidative modifications is attributed to the changes in the structural characteristics and decrease in the content of non-cellulosic components. Having in mind that the metals are highly conductive, one of the strategies that can be used to improve the fibers' electro-physical properties is their functionalization by incorporation of ions, nanoparticles, or oxides of various metals. The incorporation of silver ions leads to a decrease in jute fabrics' volume electrical resistivity by 3.0-38.5 times and provided maximum bacterial reduction for *E. coli* and *S. aureus*. Further amelioration of fibers' electro-physical properties could be achieved by the treatment with $CuSO_4$ and *in situ* synthesis of Cu-based nanoparticles on their surfaces by reduction. Exploitation in specific conditions that contribute to copper reduction will make jute fabrics able to store 21-163 times more energy from an external electric field than before the exploitation, which will extend their lifetime. The measurements of jute electro-physical properties as a function of different internal and external factors enable the prediction of its behavior in real application conditions, making it possible to design fabrics with desired properties. The chemically modified jute fabrics are particularly stable to achieve good energy accumulation in the presence of an electric field and they can be successfully used in flexible electronics, as well as, for electrical applications such as electrostatic discharge and fabric-based electromagnetic shielding devices, etc.

Except for the above-mentioned high-performance technologies, jute fabrics with improved dielectric properties could be also used for some ordinary products, such as protective clothing or textile of a specific behavior in environments sensitive to electrical discharges and home textiles (carpet). The increased production of these ordinary, as well as products with high performances, brings a considerable amount of waste in the form of fabric. Recycling in the way of producing filters for wastewaters minimizes the disposal costs of such fabrics thus contributing to "closing the loop" of their lifecycle, which is in agreement with the circular economy concept. To move towards a circular economy and to ensure the recycling and re-use of recycled fabrics, the jute fabrics with improved sorption properties were evaluated as adsorbents for various heavy metal ions, and anthraquinone dye C. I. Acid Blue 111 and Congo Red (C. I. 22120). It is worth mentioning that jute fabrics obtained after the adsorption of Zn^{2+} and Cu^{2+}-ions provided maximum bacterial reduction for *E. coli* and *S. aureus* and can be further utilized as filters for water disinfection. After use, these adsorbents can be burned and the metals recovered (*e.g.*, for catalysis), while the lignocellulosic material as abundant and low-cost waste can be used to prepare activated carbons.

Our latest investigations are focused on the preparation of jute geo-prebiotic support for cyanobacteria growth as a novel solution for damaged land rehabilitation. More precisely, raw jute fabric was subjected to atmospheric pressure dielectric barrier discharge (DBD) under different conditions (power and frequency of discharge, air as working gas, constant time of 120 s) to tailor its wettability properties which were monitored by wetting time and capillary height measurements. Special emphasis was put on the effect of aging on the mentioned properties. The biocrust inoculum survival and efficiency of biocrust restoration could be improved by increasing the availability of water during the initial phase of damaged soil rehabilitation. By tailoring geo-prebiotic polysaccharide supports' sorption properties, the viability of the cyanobacterial inoculum will be improved, the development of the biocrust accelerated, and finally, the efficiency of the biocrust carpet significantly increased.

Keywords: jute, chemical modification, atmospheric pressure plasma treatments, sorption properties, electro-physical properties, adsorbent, wastewater treatment, geo-prebiotic support, damage land rehabilitation

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N.B.: Manuscripts submitted to this Congress were not subjected to language or other corrections, except in some extreme cases. Authors are fully responsible for the content of their Abstracts.

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