2024 Conference
Conference on Biomimetics
15–17 May 2024 | Online

Extreme biomimetic approach: melting of steel and copper on carbonized 3D spongin scaffolds.

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INTRODUCTION & AIM

Extreme biomimetic is a new discipline within materials science launched in 2010 by Prof. Ehrlich. It looks for natural inspirations leading to new solutions that are far beyond human comfort zone (temperature, pressure, pH). The main idea is to use chemically and thermally stable, renewable biopolymers to produce a new generation of bioinspired composite materials never reported before [1,4,5]. Using spongin as a high thermostable, renewable and natural 3D biocomposite to produce new carbon – based and copper – based composite materials will be a major step forward in the development of bioinspired materials with a wide spectrum of possible applications such as medicine, tissue enginnering, biotechnology, nanotechnology, catalysis and modern industry (extreme temperatures) [1,4].

Spongin

Natural and renewable biopolymer extracted from naturally occuring marine sponges which are farmed around the world [1-4].

This biocomposite contains xylose, mineral phases, collagen structures, sulphur and halogens [1,4,5].

Spongin is resistant to enzymes, hydrogen peroxide, sulphuric acid, hydrochloric acid as well as ammonia [1,4].

This unique biomaterial can be carbonized at tempatures over 1000 °C with transformation into graphite without loss of its 3D architecture [1-5].

Properties of spongin – based materials [1,4]:

- high thermostability
- high strength
- toughness
- porosity
- absorbency
- elasticity
- compressibility

METHODS

Cutting small fragments and immersion in 3M HCl for 72 h

Washing with ditilled wated under pH=7 and drying at 40 °C. Immersion in 40% HF for 24 h and next washing under pH=7 and drying at 40 °C.

Carbonization in a graphite crucible in the furnace at 1200 °C for 1 h in argon atmosphere.

Applying steel or copper shavings/powder to the carbonized scaffold and melting them at 1450/1600 °C or 1100 °C (copper) in argon atmosphere in the furnace using graphite crucibles.

RESULTS & DISCUSSION

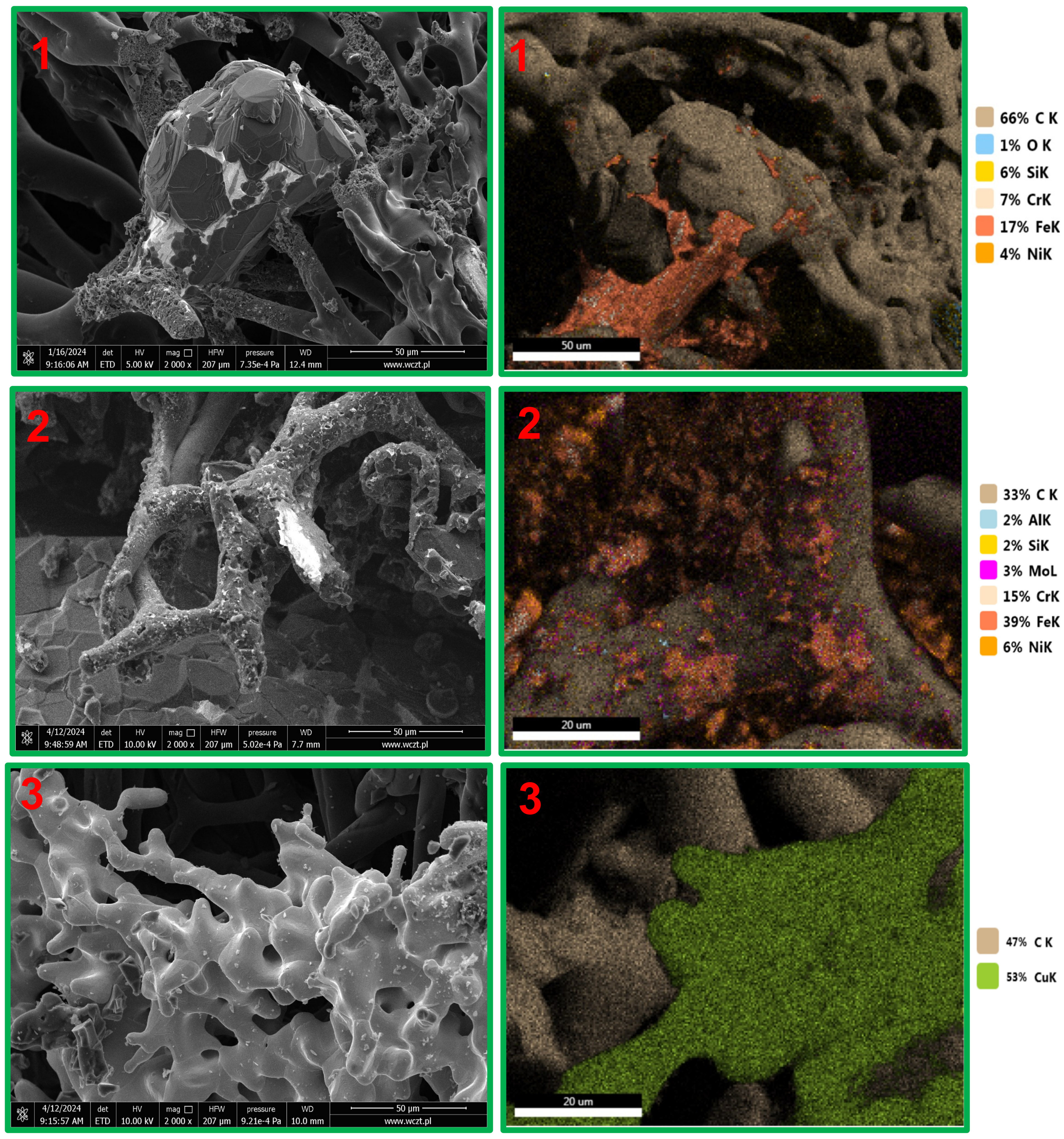

Figure 1. SEM images and elemental mapping analyses of spongin samples after steel/copper melting process: **1** – stainless steel 316L (C, Si, Mo, Cr, Ni. Fe) – 1450 °C; **2** – carbon steel C45 (C, O, Si, Cr, Fe) – 1600 °C; **3** – copper powder – 1100 °C.

Element	%C	%O
Sponge after HF carbonized - control	97.13	2.87

Table 1. EDS analysis of control sample (carbonized spongin after HF treatment at 1200 °C).

CONCLUSIONS & FUTURE WORK

- Using extreme biomimetic approach, new composite materials with unknown properties were obtained,
- In all analyzed samples a reaction occured between spongin and steel or copper during the melting process – it was proven by SEM analyses and elemental mapping (each sample shows the content of iron or copper which were not present in the control sample),
- Due to the nanocrystalline metallic phase which is homogenously distributed on the surface of carbonized spongin, microfibres separated from the metallized 3D construct show the appearance of magnetic properties (only in the case of iron – spongin composites),
- Obtained materials will be tested in the future for a large – scale industrial applications (mechanical, thermal and durability tests),
- In further tests, other metals and alloys will be checked, e.g. Mn, Cr, Ni, Ti. It will be also checked the saturation of the sponge skeleton with selected metal before the carbonization process.

References:
1. H. Ehrlich, Marine Biological Materials of Invertebrate Origin. 1st ed. Springer, **2019**,
2. A. Kubiak et. al. Mar. Drugs **2023**, 21, 460,
3. A. Kubiak et. al. Biomimetics **2023**, 8, 533,
4. B. Leśniewski et. al. Letters in Applied NanoBioScience 2023, 12,
5. D. Tsurkan et. al. Adv. Mater. 2021, 33.

National Science Centre Poland

This research was funded by the National Science Centre within the framework of the project MAESTRO 12 No. 2020/38/A/ST5/00151.