

# Chitosan-alginate sponges loaded with silver nanoparticles for biomedical application

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Chitosan has been recently employed for chitosan-based delivery systems or as haemostatic sponges. It is a cationic polymer, so it can be successfully combined with anionic sodium alginate. In this work we loaded sponges based on Ch, Alg and their combinations (Fig.1) with Ag nanoparticles (AgNPs) and examine their antimicrobial effect against *E.coli* and *S. aureus* and mixed-species biofilms (*P. aeruginosa* and *E. coli*) depending on AgNPs concentrations.

Fig. 1. SEM images of Ch/Alg composite materials

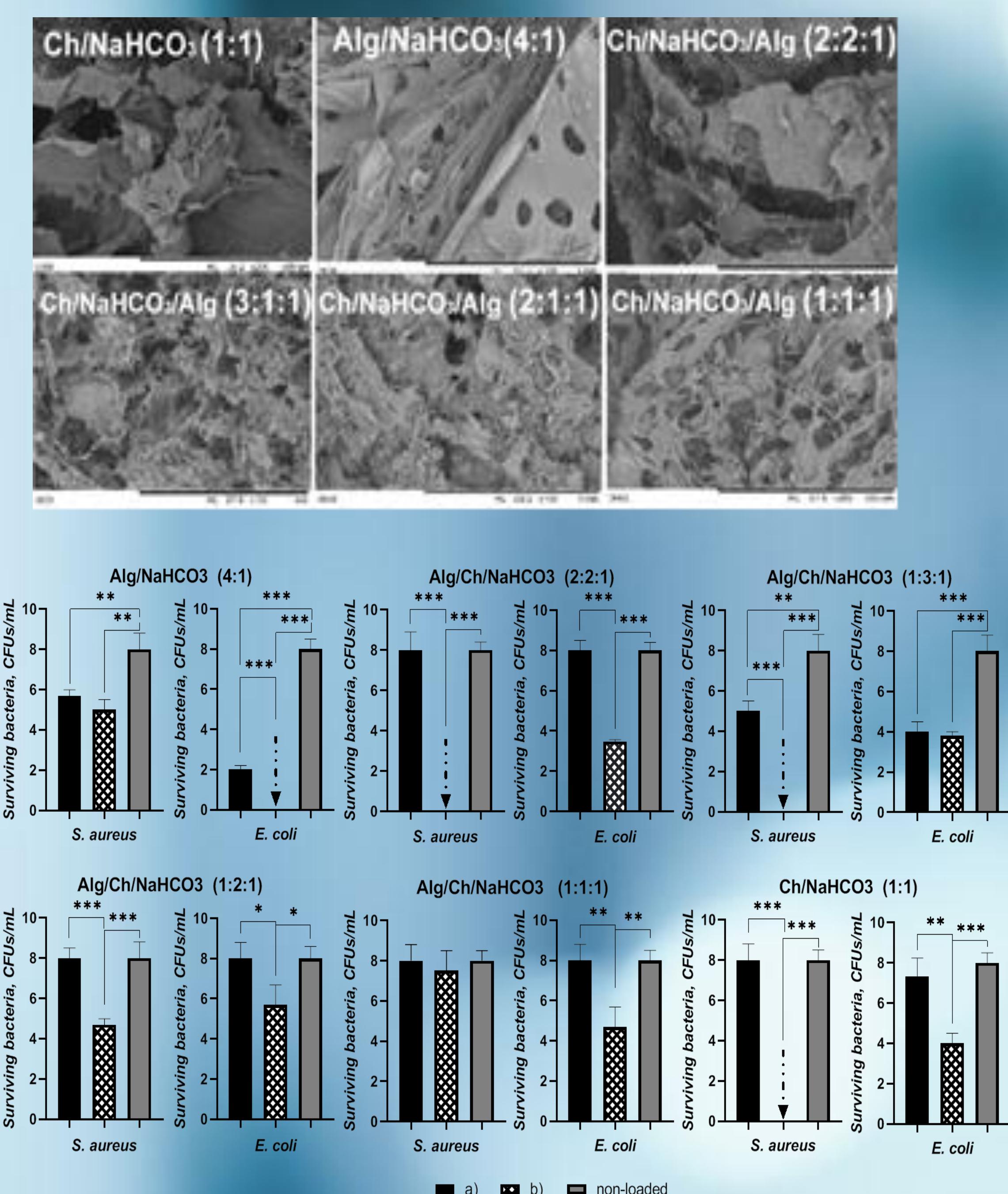


Fig. 2. Antimicrobial effect of composite materials (non-loaded samples, samples (a) and samples (b)) against *S. aureus* and *E. coli* depending on AgNPs concentrations

The antibacterial activity was defined using zone inhibition test and pour plate technique. The concentration of the bacterial suspension was  $10^5$  CFU/ml. Most samples showed inhibitory effect on bacteria growth at AgNPs concentrations from  $3.03 \cdot 10^{-6}$  (a) to  $8.42 \cdot 10^{-6}$  (b). Sponges doped with AgNPs prevented bacterial growth more effectively than control samples. Moreover, sponge Alg/NaHCO<sub>3</sub> possessed bactericidal activity in both (a) and (b) compositions. Sponge Ch/NaHCO<sub>3</sub> demonstrated stronger bactericidal action for sample (b). Adding of AgNPs improves the antibacterial effect of Ch, Ch/Alg and Alg sponges against Gram-negative bacteria.

Table 1. Antibacterial properties of Ch/Alg composite materials

Composition	Zones for inhibition [Ag] in the sample g/g	Zones for inhibition, mm	[Ag] nanoparticles in samples, g/g	Effects of the concentration of bacteria $10^5$ CFU	
				Inhibitory	bactericidal
Alg/NaHCO <sub>3</sub> 4/1	a	$8.85 \cdot 10^{-6}$	—	$3.43 \cdot 10^{-6}$	—
	b	$5.73 \cdot 10^{-6}$	1.5	$3.26 \cdot 10^{-6}$	—
	cont	—	—	—	+
Ch/NaHCO <sub>3</sub> 1/1	a	$3.99 \cdot 10^{-6}$	0.5	$5.35 \cdot 10^{-6}$	—
	b	$7.86 \cdot 10^{-6}$	2	$8.42 \cdot 10^{-6}$	—
	cont	—	0.25	—	+
Ch/Alg/NaHCO <sub>3</sub> 2/1/2	a	$7.72 \cdot 10^{-6}$	0.5	$5.74 \cdot 10^{-6}$	—
	b	$7.16 \cdot 10^{-6}$	1.5	$8.06 \cdot 10^{-6}$	—
	cont	—	—	—	+
Ch/Alg/NaHCO <sub>3</sub> 3/1/1	a	$3.68 \cdot 10^{-6}$	1	$3.03 \cdot 10^{-6}$	—
	b	$6.32 \cdot 10^{-6}$	1	$6.32 \cdot 10^{-6}$	—
	cont	—	1	—	+
Ch/Alg/NaHCO <sub>3</sub> 2/1/1	a	$4.27 \cdot 10^{-6}$	1	$3.75 \cdot 10^{-6}$	—
	b	$8.30 \cdot 10^{-6}$	1	$8.00 \cdot 10^{-6}$	—
	cont	—	0.25	—	—
Ch/Alg/NaHCO <sub>3</sub> 1/1/1	a	$2.90 \cdot 10^{-6}$	—	$2.90 \cdot 10^{-6}$	—
	b	$5.20 \cdot 10^{-6}$	1	$4.00 \cdot 10^{-6}$	—
	cont	—	1	—	+

Table 2. Mean pore size of the obtained sponges, mm<sup>2</sup>

Sample composition	Mean pore size of the obtained sponges, mm <sup>2</sup>
Alg/NaHCO <sub>3</sub> (4:1)	$2.64 \cdot 10^{-3}$
Alg/Ch/NaHCO <sub>3</sub> (2:2:1)	$2.43 \cdot 10^{-2}$
Alg/Ch/NaHCO <sub>3</sub> (1:3:1)	$7.0 \cdot 10^{-3}$
Alg/Ch/NaHCO <sub>3</sub> (1:2:1)	$5.67 \cdot 10^{-3}$
Alg/Ch/NaHCO <sub>3</sub> (1:1:1)	$1.01 \cdot 10^{-3}$
Ch/NaHCO <sub>3</sub> (1:1)	$4.59 \cdot 10^{-3}$

**Anknowledgments:** Government Program "State order for scientific-technical (experimental) development and scientific and technical production". Project 0118U003577 Effectiveness of chitosan-nanometals antimicrobial action against clinical multiresistant strains.