

# DEVELOPMENT OF ION EXCHANGE MEMBRANE WITH ANTIMICROBIAL ADDITIVES

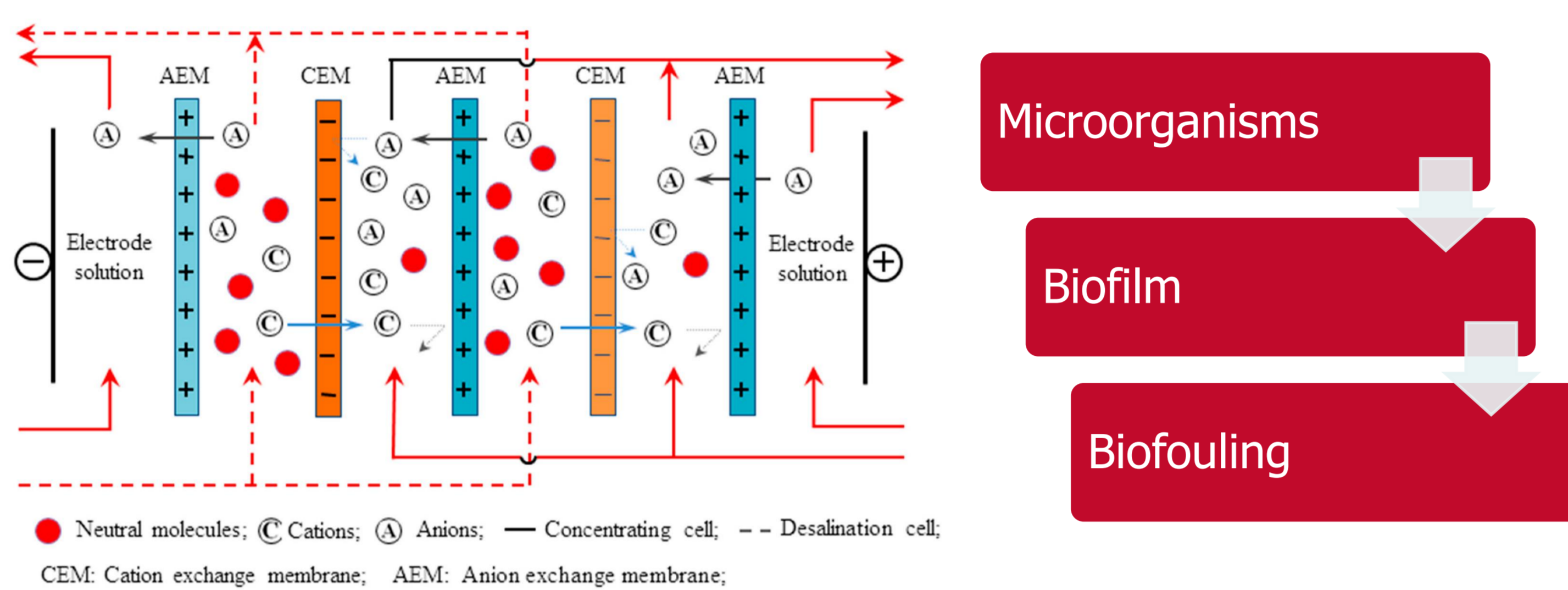
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## Objectives

This work is focused on restriction of biofouling in electromembrane processes. Two additives were used to mitigate adhesion of microorganisms on the surface of anion exchange membrane. Physical, electrochemical and antibacterial properties were assessed.

## Biofouling



## Material and methods

### Modified anion exchange membranes

- two different additives were used for anion modification
  - silver-glass powder with silver-magnesium-aluminum phosphate complex **Sanitized<sup>®</sup> BC A 21-41** (SANITIZED AG) in 0.2 wt % and 0.6 wt%
  - PE granulate with pyriothione zinc **Sanafor<sup>™</sup> PO-5** (Janssen PMP) in 1.0 wt% and 4.0 wt%
- reference sample without additives was prepared as AM standard

### Overview of tests

Mechanical properties	Physical electrochemical properties	Antibacterial properties
Tensile tests	Permselectivity measurement	DNA concentration measurement
	IEC measurement	Inhibition zone test
	Resistance measurement	Cultivation test on agar

## Results

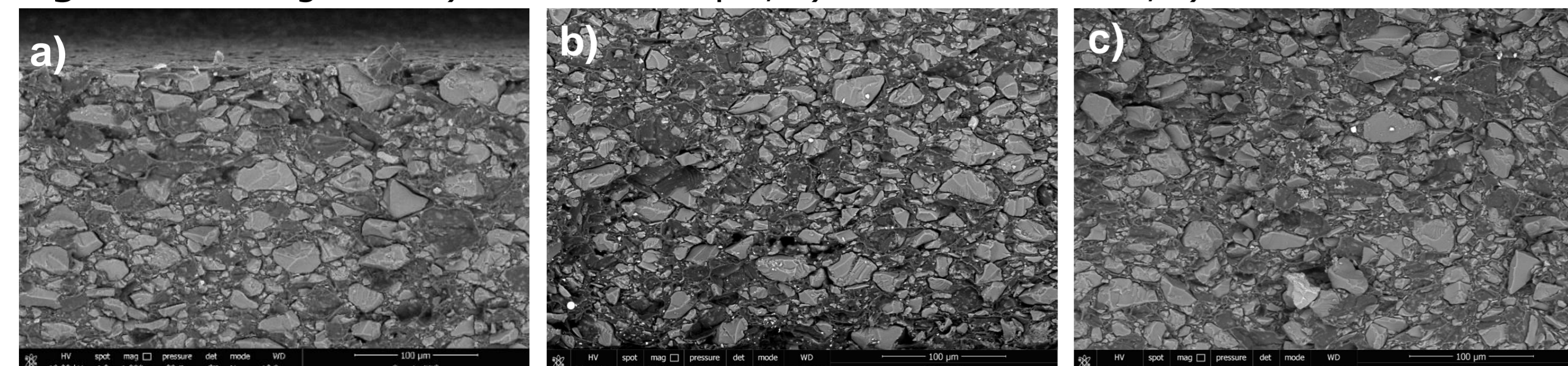
### Tensile measurement

Mechanical properties were measured on the Tinius Olsen H5KT according to EN ISO 527-3. Results are shown in Tab. 1.

Tab. 1: Results of tensile measurement

Membrane	$\sigma$ (MPa)	$\Delta l$ (%)	E (MPa)
AM Standard	1.485 ± 0.047	9.92 ± 1.54	59.9 ± 1.6
AM Sanitized 0.2 wt%	1.454 ± 0.036	9.34 ± 0.59	58.6 ± 0.8
AM Sanitized 0.6 wt%	1.547 ± 0.036	11.43 ± 0.74	56.9 ± 1.7
AM Sanafor 1.0 wt%	1.483 ± 0.035	14.21 ± 0.58	52.2 ± 0.3
AM Sanafor 4.0 wt%	1.438 ± 0.049	15.95 ± 0.26	52.0 ± 1.4

Fig. 1: SEM images of: a) reference sample, b) Sanitized 0.6 wt%, c) Sanafor 4.0 wt%



### Resistance measurement

The values of the specific resistance  $R_A$  and the surface resistance  $R_S$  of the anion exchange membrane are shown in Tab. 2.

Tab. 2: Results of resistance measurement

Membrane	$R_A$ ( $\Omega \cdot \text{cm}^2$ )	$R_S$ ( $\Omega \cdot \text{cm}$ )
AM Standard	4.90 ± 0.12	106 ± 0.3
AM Sanitized 0.2 wt%	3.24 ± 0.09	72.8 ± 0.1
AM Sanitized 0.6 wt%	3.00 ± 0.06	66.0 ± 0.1
AM Sanafor 1.0 wt%	3.16 ± 0.09	68.4 ± 0.1
AM Sanafor 4.0 wt%	2.91 ± 0.09	64.3 ± 0.1

### Ion exchange capacity and permselectivity

The values of the ion exchange capacity (IEC) and permselectivity (P) are shown in Tab. 3.

Tab. 3: Results of ion exchange capacity and permselectivity

Membrane	IEC ( $\text{mekv} \cdot \text{g}^{-1}$ )	P (%)
AM Standard	2.30 ± 0.04	88.2 ± 0.12
AM Sanitized 0.2 wt%	2.27 ± 0.03	88.6 ± 0.09
AM Sanitized 0.6 wt%	2.20 ± 0.04	87.6 ± 0.10
AM Sanafor 1.0 wt%	2.30 ± 0.06	88.0 ± 0.12
AM Sanafor 4.0 wt%	2.28 ± 0.02	87.9 ± 0.13

### DNA concentration

Antibacterial properties of modified ion exchange membrane were tested through measuring total DNA extracted from membrane surface. DNA was isolated by FastDNA SPIN Kit for Soil. Results are displayed in Fig. 2.

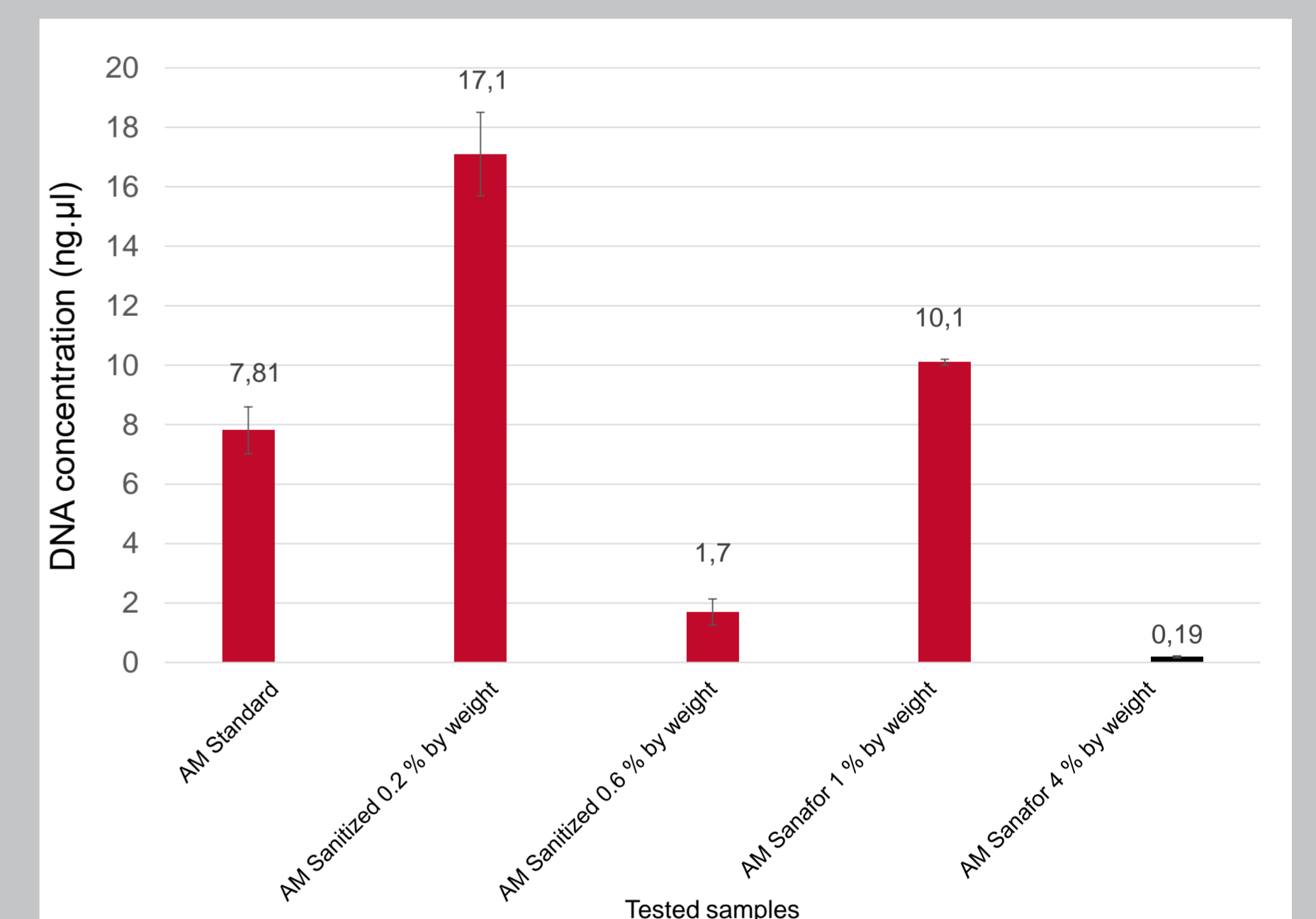


Fig. 2: DNA concentration extracted from membranes

### Inhibition zones

Bacterial colonization reached the membrane edge for both strains *S. Aureus* and *E. coli*, moreover, at all concentrations tested (Fig. 3). It indicates the stability of additives in membrane matrix.

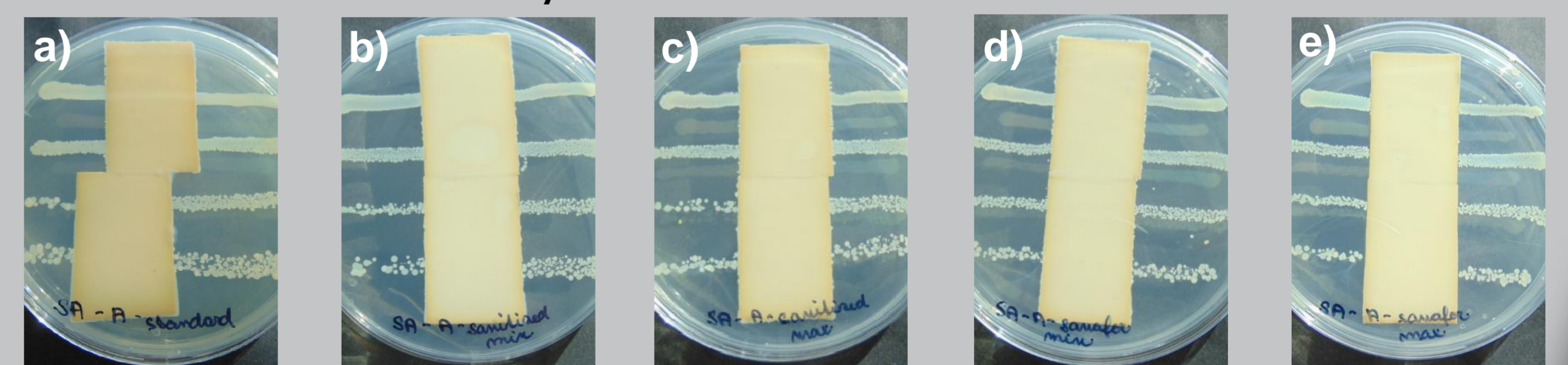


Fig. 3: Inhibition zone for *S. Aureus*: a) reference sample, b) Sanitized 0.2 wt%, c) Sanitized 0.6 wt%, d) Sanafor 1.0 wt%, and e) Sanafor 4.0 wt%

### Conclusions

- biofilm growth on the membrane surface was more suppressed with higher concentration of additives
- by adding additive the resistance has been reduced
- performed modification did not significantly affect the mechanical properties of membranes