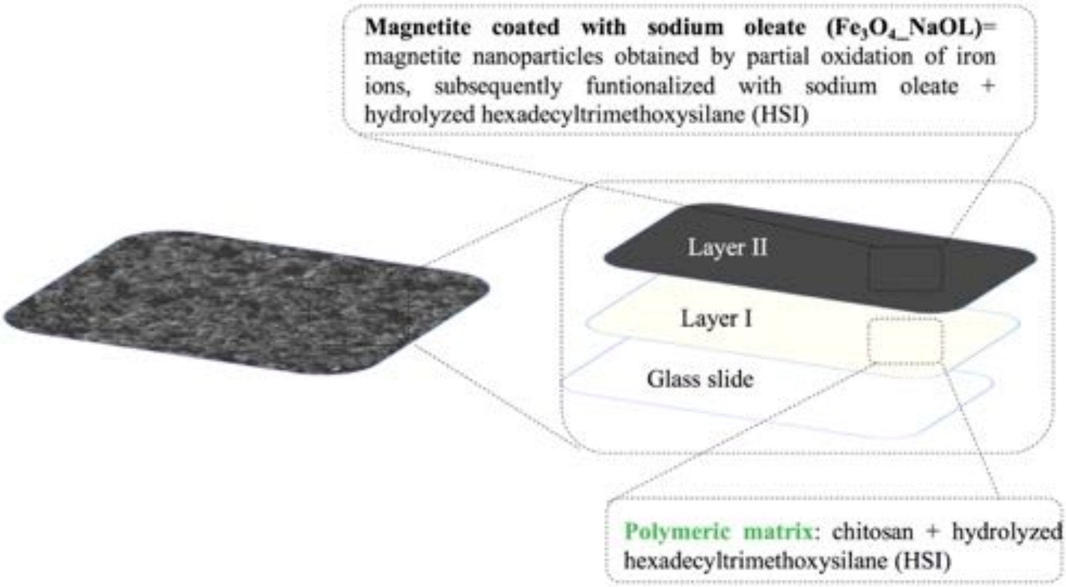
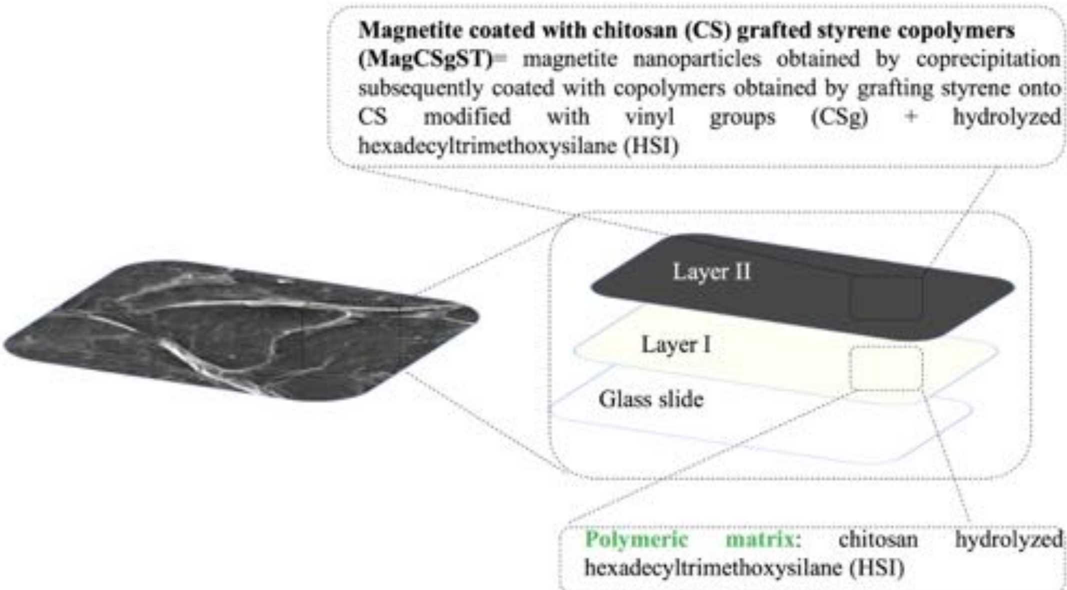
Objective 1. Composite coating optimization and characterization

1.1. Synthesis reproducibility study
1.2. Coating characterization regarding morphology, adherence to substrate, contact angle with water drops

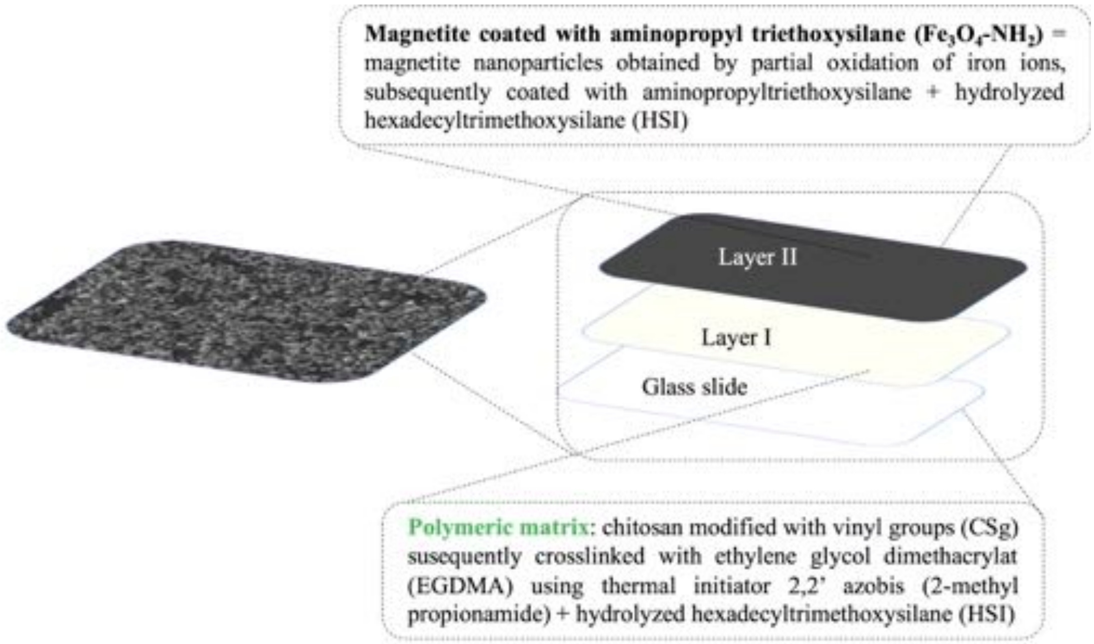
<u>Results and conclusions</u>
The formulations for three types of hybrid films were optimized:
A. Film deposited layer by layer by spray coating: first layer: chitosan + hydrolyzed HSI; second layer: magnetite coated with sodium oleate + hydrolyzed HSI



B. Film deposited layer by layer by spray coating: first layer: chitosan + hydrolyzed HSI; second layer: magnetite coated with chitosan grafted styrene copolymer+ hydrolyzed HSI



C. Film deposited layer by layer by spray coating: first layer: chitosan modified with vinyl groups (CSg) crosslinked with ethylene glycol dimethacrylate + hydrolyzed HSI; second layer: magnetite coated with 3-aminopropyl triethoxysilane+ hydrolyzed HSI



- All the formulations were reproducible;
- The contact angle with water drops was in the range of 140-160^0 for the type A film, 120-140^0 for the type B film and respectively 143-158^0 for the type C film. The average hydrophobicity increases in the order B<A<C;
- The adhesion to substrate estimated from the critical force that separates the film from the support increases in the order C<A<B (8.2mN; 18mN; 84mN);
- All three types of formulations evidence nanoparticle generated surface roughness.

Objective 2. Testing composite ice-repelling performance on various substrates

2.1. Testing of samples coated with composite materials in contact with super-cooled water in order to determine the probability of ice formation. Comparison with uncoated samples.

Results and conclusions

Three sets of 10 glass slides, each coated with one type of hybrid film were tested in a climatic chamber with simulated freezing rain or fog (64% humidity) at -18^{0}C. The tests were repeated three times. The number of ice nuclei formed on each slide was counted on video recordings.
Comparative images from the video recordings taken during the simulated fog test are presented in Figure 1.

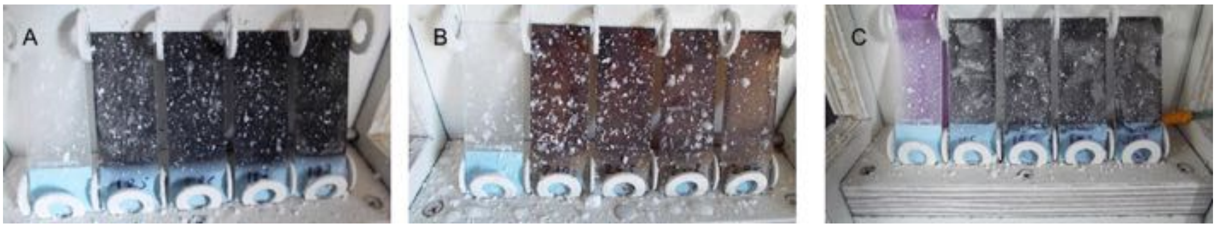


Figure 1: Comparative images of the type A, B and C hybrid films from the video taken during the simulated fog test (64% moisture, -18^{0}C)

No large drops were formed on the type A films, while some of the type B and C coatings evidenced between 2 and 15 large drops. The estimated probability for ice formation increases in the order C<A<B, as shown in Figure 2. The minimum probability for ice accretion, namely 72% was obtained for the type C hybrid film.

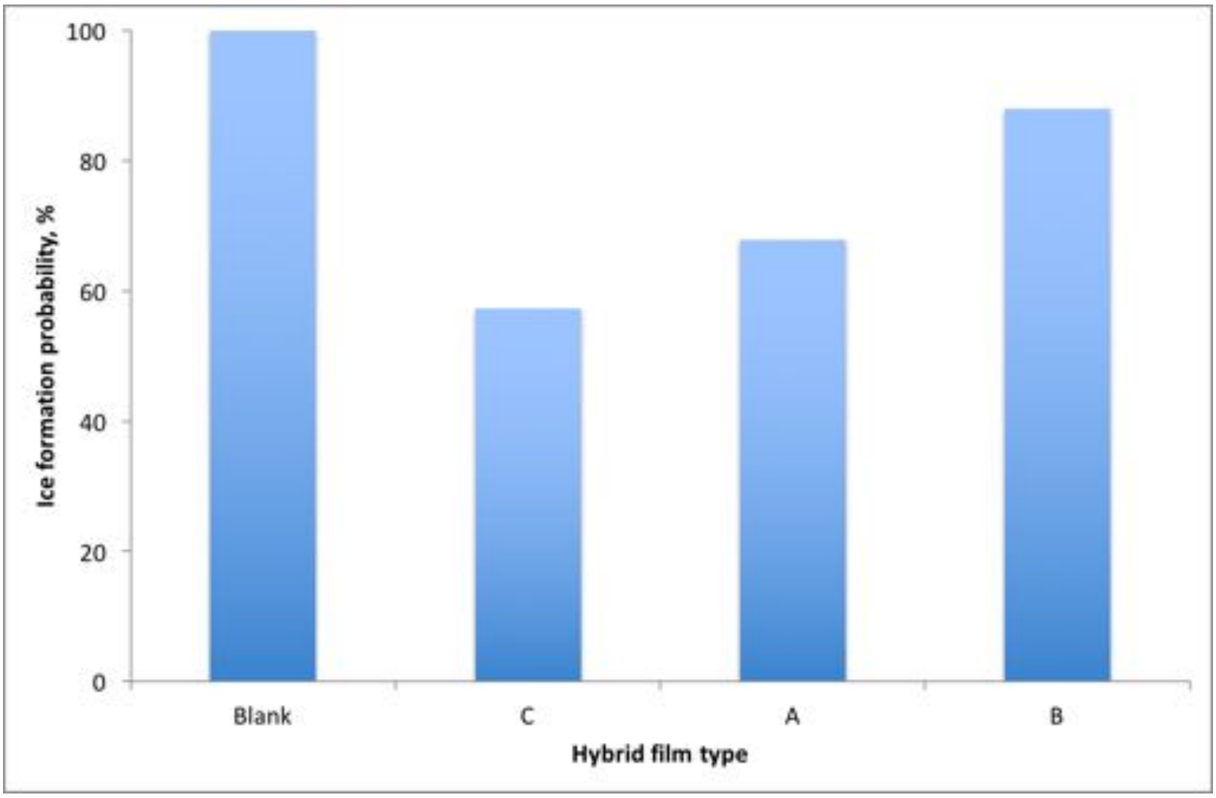


Figure 2: Estimated probability for ice formation during the simulated fog test (64% moisture, -18^{0}C)

Comparative images of the type A, B and C hybrid films during the simulated icing rain are presented in Figure 3. Large drops were formed on all three types of coatings. The estimated probability for ice accretion increases in the order A<C<B, as shown in Figure 4, mentioning that the performance of type A and C coatings is comparable (41 and respectively 42%).

Figure 3: Comparative images of the type A, B and C hybrid films from the video taken during the simulated freezing rain test (-18^{0}C)

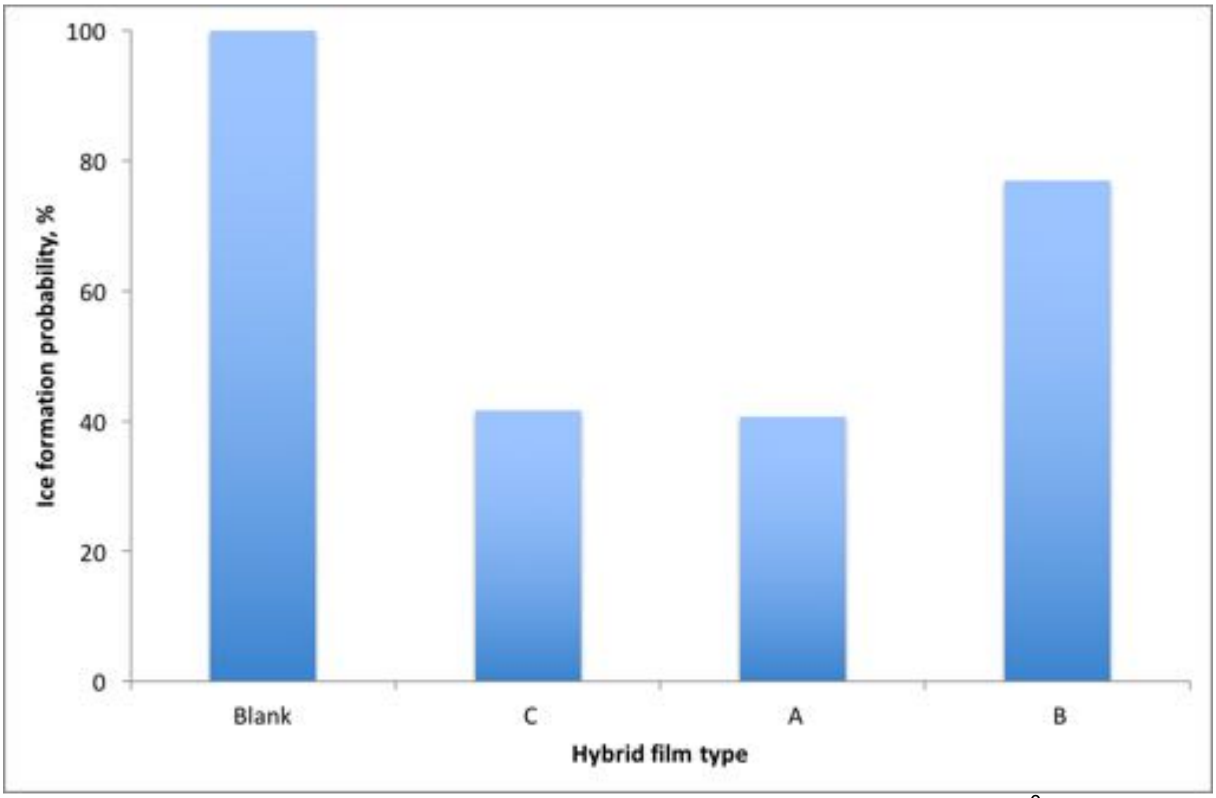


Figure 4: Estimated probability for ice formation during freezing rain (-18^{0}C)

- The average estimated probability for ice accretion was lower on the coated slides than on the uncoated ones in both tests and for all three types of hybrid films;
- The results show that the coatings are more efficient in preventing ice formation in simulated freezing rain than in cold fog. The probability for ice occurrence was reduced by about 60% by the type A and C coatings in the freezing rain test. The type C coating is the most promising one for the freezing fog conditions, in which it proved efficient for reducing the ice accretion probability by about 30% compared to the uncoated surface.