Greenhouse Optimization through Anti-Fogging PMMA

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MOTIVATION

The population of the planet is reaching unsustainable levels as it faces shortage of resources like food. A major contributor to maintaining an adequate food production is the use of greenhouses, which for the U.S. has an annual production value of approximately $20 billion. An optimization in sunlight accessibility could increase the efficiency of this production significantly. A major problem faced by the greenhouse industry is fogging of the windows, causing a dramatic drop in sunlight transmission. Creation and implementation of anti-fogging windows would alleviate this problem, and thus result in more food per kg CO_2!

Theory

Condensation of water on surfaces usually happens dropwise. This causes a significantly decrease in the surface transparency. However, strongly hydrophilic materials can exhibit changed properties, where immediate thin film creation is observed instead. This leads to a far more efficient transmittance of sunlight to the crops!

A widely used material for greenhouse windows is Poly(methyl methacrylate) (PMMA). PMMA has an intrinsic contact angle of ~70°, but is in itself not hydrophilic enough to enable this immediate thin film creation and cause anti-fogging behavior. Through texturing of the PMMA at nanoscale the apparent contact angle can be reduced, but currently not enough to enable anti-fogging properties. It calls for alternative methods, and recent investigations have showed the exciting possibility of further, albeit temporary, reduction of the contact angle using plasma treatment activation.

Concept

Here presenting a 3-stage proposition towards the development of permanent anti-fogging PMMA surfaces to be used in greenhouse optimization.

1. Achieve temporary anti-fogging PMMA surfaces using nanotexturing and plasma activation.
2. Identify chemical additives mimicking the effect of plasma activation but tailoring permanent properties.
3. Upscale production through the technique of extrusion coating.

Methods

In this study the first step of activating PMMA surfaces with different nanotexturings were taken. This was accomplished using the plasma system ATTO produced by Diener. Different gasses, plasma pressures, and treatment durations were investigated tailoring a recipe minimizing the contact angle. The plasma activated surfaces were characterized using an Attension Theta Optical Tensiometer to measure the advancing and receding contact angles using the technique of inflation and deflation.

Conclusion

The investigation has identified a recipe for plasma activation of PMMA reducing the advancing water contact angle to <15°. The result anticipates the possibility of enabling immediate thin film creation during water condensation, and having anti-fogging properties. Future determination of the critical contact angle defining the transition between fogging and anti-fogging behavior can guide choices of chemical additives towards permanent antifogging PMMA surfaces. It will help the greenhouse industry to mitigate food shortage!