Cold plasma for food application

Identification

Key words: atmospheric pressure plasma, cold pasteurisation, low-pressure plasma, microwave plasma, glow discharge plasma, decontamination, sterilization

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How does it work?

Primary objective: Decontamination/sterilisation of food products surface
Gas plasma is a neutral ionized gas containing on the one hand, charged particles, free electrons and ions, and on the other hand neutral reactive species such as atoms and molecules. When such ionized gas is submitted to an electric field, charged particles are accelerated producing collisions with the atoms and molecules. Consequences of these collisions are new charged particles (ions, electrons and free radicals), chemical reaction with sample surface and creation of photons in the UV range. UV radiation and collision with heavy ions have a strong effect on the survival of biological species (bacteria, virus...), creating important structural damage on the cell membrane. Because sample temperature remains mostly unchanged during processing, the technology is considered to be a non-thermal one.

For food application there are two general principles:
1. The low-pressure plasma (Fig. 1) consists of creating a vacuum inside a cavity (called plasma reactor) and filling it partially (vacuum remains at 0.01 – 0.02 MPa in the plasma reactor) with a gas such as argon, N2O, N2 or oxygen. Plasma can be generated by a radiofrequency field (typically of 13.6 MHz) between two electrodes or by microwave energy (typically 2450 MHz) from an antenna or emitter.
2. The atmospheric plasma (Fig. 2) consists of creating a plasma at ambient pressure (0.1 MPa) using a high potential difference between two electrodes placed in a gas mixture. There are different ways to generate atmospheric plasma such as Radiofrequency plasma (RF plasma), corona discharge plasma, resistive barrier discharge (RBD) plasma and gliding arc discharge plasma. For food application the RBD discharges and One atmosphere uniform glow discharge plasma (OAUGDP) system look promising. In the first one, a high-resistivity material is inserted in the discharge gap between a high voltage electrode (HV Electrode) and a low voltage electrode (Ground Electrode) connected to a transformer. The barrier limits the discharge current thus preventing uncontrolled arcing generation. For the second one a gas mixture (argon or CF4) is blown between the two electrodes where a high potential difference is applied creating a stable glow discharge and thus the plasma.

Further effects include:
- Decontamination effect on Listeria monocytogenes in cheese and cooked ham or Salmonella on the surface shell eggs.
- Reactive oxygen species (ozone, oxidation of amino acids and nucleic acids, lipid oxidation) might occur during processing, especially for the atmosphere pressure system.
- Oxidation of vitamins C and E, lipids or other sensitive food ingredients.
- Uniform and nanometric coating of plastics for the food sector using a low-pressure plasma system.
What can it be used for?

**Products**
Cooked ham, cheese, legumes, dry fruits, eggs & plastics (PP, PE & PET).

**Operations**
In the low-pressure plasma technology, chambers of up to 12,000 liters can be used with a vacuum mechanism to replace the air by a noble gas; even if it is a batch technology, short cycle plasmas system can be inserted in an automatic process line.
In the atmospheric plasma, distance between electrodes (maximum 8 cm) and treatment time are critical parameters as well as the surface area; samples can be situated on a conveyor belt for a continuous processing.

**Solutions for shortcomings**
For some industrial processes it is important to have a pre-treatment of the products or packaging surface. Cold plasma, as well as light pulse of UV, can be a simple and cost benefit technology to fulfil this goal.

What can it NOT be used for?

**Products**
Foodstuff with high lipid content and/or high vitamin content.

**Operations**
It is a surface decontamination on the first millimetres; the centre of the product is not affected.

**Other limitations**
Unwanted burns might occur just below the surface and damage the texture of the food products.

**Risks or hazards**
Depending on the gas mixture, the one atmosphere uniform glow discharge plasma system can generate a high amount of ozone.

Implementation

**Maturity**
The technology using vacuum pumps exists for industrial applications other than food industry. The RF-Plasma have been proven on a small industrial scale, the OAUGDP exists at small scale for pilot plant applications.

**Modularity**
The modularity will depend on the application and the chosen technology (atmospheric plasma, nitrogen plasma...).

**Consumer aspects**
Up to now there is no information on consumer acceptance of this technology.

**Legal aspects**
The system can generate UV photons and ozone gas, thus the local legislation on UV and ozone must be applied.

**Environmental aspects**
No information is available, but the environmental impact might be associated with high voltage and ozone generation.

Facilities that might be interesting for you

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<th>Title</th>
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<td>Cold Plasma unit FBR</td>
<td>Wageningen UR - FBR</td>
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Further Information

Institutes
Wageningen UR - FBR, CRIC

Companies
Diener, OMVE Netherlands

References

Source: