Cold plasma application on packaging materials

Cold plasma for packaging application

### Identification

<table>
<thead>
<tr>
<th>Key words</th>
<th>Cold plasma, sterilisation, microorganisms, bottle, antimicrobial, non-thermal plasma, decontamination, RF</th>
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<tbody>
<tr>
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<td>Completed by</td>
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### How does it work?

<table>
<thead>
<tr>
<th>Primary objective</th>
<th>Rapid and effective sterilization and deodorization of surfaces e.g. of PET or glass bottles before filling and dielectric surfaces.</th>
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<tbody>
<tr>
<td>Working principle</td>
<td>Generally cold plasma technology is used for inactivation of micro-organisms (vegetative and sporulent form) on the surface of products and packaging materials [5]. The oxidative radicals are released that acts on biological targets and damage their cell membrane. It is a non-thermal sterilization and can be used for heat sensitive packaging materials. It is energy-efficient way with a minimum of damage to the product. For products such as cut vegetables and fresh meat there is no mild surface decontamination technology available at the moment. The Principle of atmospheric cold plasma is based on a pulsed RF discharge in gases to which an electric charge has been applied (nitrogen, argon, air) at atmospheric pressure creating unsteady plasma on the treated surface. Standardly the cold plasma equipment consists of high voltage generator which is connected to an electrode. It is a metal rod which contained in a grounded metal tube. A carrier gas is introduced into the space between the rod and the tube and forms a plasma cloud. The plasma is continuously transported out of the discharge region by the carrier gas to produce its characteristic afterglow. This plasma jet is suitable for flat surfaces. For bottles it is more suitable RF (Radio frequency) FLASH PLASMA [3]. RF high-current discharge is used in such a manner that no electrode is introduced into the bottle and the bottle walls themselves stabilize the plasma. The bottle is used as a plasma generator and the plasma generated in it, instead of being introduced into the bottle it is, in fact, ejected from the bottle. The discharge is initiated by means of a central electrode, located outside of the bottle above its neck. A second, external, grounded electrode surrounds the bottle. Plasma is generated in the air contained in the bottle before treatment. A small portion of argon is eventually injected through the central electrode to facilitate and localize the plasma ignition. Temperature inside bottle does not exceed 50°C. Decontamination of one bottle takes about 20 ms [3].</td>
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### Images

#### Additional effects
- deodorization of the inside of PET bottles before filling

#### Important process parameters
- Ignition voltage, frequency of RF pulses, length of pulses, main input power, mean pulse current, exposure time, type of gas, density, temperature, size
Important product parameters

What can it be used for?

**Products**
- surface of packaging materials (bottles)

**Operations**
- Sterilisation of bottles before filling of a product.

**Solutions for shortcomings**
- This technology is mainly suitable for PET bottles because of low temperature and high speed of sterilisation.

What can it NOT be used for?

**Products**
- 

**Operations**
- 

**Other limitations**
- Bacteria in deeper biofilm layers survive better after the plasma treatment than without or at small layer of biofilm. It was found that the rate of inactivation e.g. of S. typhimurium is inversely proportional to initial bacterial concentration [2]. There can be problem with spores of some microorganisms - no significant inactivation e.g. for Geobacillus stearothermophilus [6].

**Risks or hazards**
- Electrodes that are used in gas discharges degrade over time. Metals that are evaporated at the electrode surface may end up as unintended additives.

Implementation

**Maturity**
- There exist many lab scale plasma jet equipments, but experiments with RF Flash Plasma for industrial use have been performed as well. The device was integrated into an industrial-filling machine for in-line sterilization and deodorization of the inside of PET bottles before filling and for caps and bottle neck sterilization before closing. The method allows cold, aseptic filling [3].

**Modularity**
- There is no problem with implementation of this technology to industrial-filling machine. The estimated cost (investment and operating cost) of this system is substantially lower than systems based on other methods.

**Consumer aspects**
- The process has no harmful effect on treated bottles or on beverages filled into the bottles after treatment.

**Legal aspects**
- The system can generate UV photons and ozone gas, thus the local legislation on UV and ozone must be applied. Generally speaking novel food legislation can be applied if the technology was not broadly used before July 12, 2002. Regulation (EC) N°258/97 of the European Parliament and of the Council as of 12/07/2002

**Environmental aspects**
- Small quantity of ozone and nitrogen dioxide and possibly NH3 are produced during the RF flash discharge in a PET bottle, which causes a characteristic odour after treatment. Experiments with filling of distilled water showed that there was neither detectable ozone nor ammoniac and that the concentration of nitrogen oxide ions was much lower than the allowed limit.
Facilities that might be interesting for you

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<thead>
<tr>
<th>Title</th>
<th>Institute/company</th>
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<tbody>
<tr>
<td>Cold Plasma unit FBR</td>
<td>Wageningen UR - FBR</td>
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Further Information

<table>
<thead>
<tr>
<th>Institutes</th>
<th>Institute for plasma technology, INP Greifswald, VITO</th>
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<tr>
<td>Companies</td>
<td>OMVE Netherlands, AURION, K-Plasma</td>
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Source: