THE CORONA DISCHARGE, ITS PROPERTIES AND SPECIFIC USES

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Discharges in gases at high pressure (above a few hundreds of torrs) can be achieved by different means without leading to sparks and subsequent drawbacks. Corona discharges is one of them, of great importance.

These discharges develop in inhomogeneous electrical fields, using electrodes of very different radius of curvature, such as wire/cylinder, wire/plane, point/plane. This electrode asymmetry governs the discharge behaviour, dividing the gap in two regions: The high field region, close to the electrode of smaller radius of curvature, where ionization can take place and initiate the discharge, and, beyond, the low field region, characterized by drift processes, where ionization processes can only develop in propagating filamentary channels (streamers) when such channels form. Under dc conditions, the dominating phenomenon in this region is an unipolar ion flow drifted from the high field region to the low field electrode. This ion flow governs the UI curve of the discharge. When streamers develop in superposition in the diffuse discharge elaborated by the ion flow, they give rise to short current pulses, on the order of 100 ns duration, which can have milliamperes amplitude. These streamers can be regarded as instabilities which, enough fed, can lead to sparking discharges.

Charges creation and transport through the gap need only a small part of the injected energy. Most of this energy is spent in dissociation and excitation processes, leaving the gaseous medium cold but in a highly activated state. These properties make a good tool of the corona discharge as a chemical reactor for synthesis or for surface treatment. For the latter class of applications, one takes particular advantage of the specific aerodynamic properties of the corona discharge which creates an important gas flow movement from the stressed electrode, through momentum transfer between ion and neutral species.

The big advantage of these reactors is to generate high energy electrons in a gas which remains cold. This can be of particular interest for synthesis of products instable at high temperatures. For instance, this is the case for production of ozone which proceeds through oxygen dissociation, thus needing electron energies higher than 3.5 eV, but which is rapidly destroyed when the gas temperature increases.

While crossing the drift region, the ions tend to a stabilized state through modifications strongly dependent on the gas composition. Impurities often play an important role in the gas evolution, for instance water vapour traces which give rise to hydrated ions. Collected by surfaces which generally are already covered with water molecules, the ions create a situation
similar to the double-layer in electrolytes. Different experimental evidences have been found in support of an electrochemical analogy between the corona activated gas and an aqueous electrolyte. Furthermore, the surface modifications cannot be considered without taking into account the other phenomena than the chemical ones, for instance atom migration which can be induced by the deactivation processes through which the internal energy gained by the gaseous species is lost on the surfaces. Grafting, deposition, cleaning processes can be achieved by corona discharges which now find an increasing number of applications in the field of surface treatment.