Development of dielectric barrier discharge (DBD) atmospheric plasma reactors for degradation of gaseous, liquid, and solid waste

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Introduction

In general, plasma processes can already be considered as inherently environmental technologies. Plasma processes enable resource saving through high energy utilization efficiency and thus, are environ-mentally friendly technologies. Atmospheric pressure discharges (APDs) are useful because of their specific advantages over low-pressure ones. They do not need expensive vacuum equipment, and generate nonthermal plasmas, which are more suitable for assembly line processes. Hence, this category of discharges has significant industrial applications. The use of a dielectric barrier in the discharge gap helps prevent spark formation. DBDs exhibit two major dis-charge modes: filamentary and glow (homogeneous). The glow discharge mode has obvious advantages over the filamentary one for applications such as treatment of surfaces and deposition of thin films. Glow mode discharges with average power densities comparable to those of filamentary discharges are of enormous interest for applications in which reliable control is required. In the present work several reactor designs and results on the degradation of refrigerant gases using the tubular plasma reactor for continuous degradation of gaseous substances are presented.

Experimental part

a) Reactor for solid samples and polymer foils

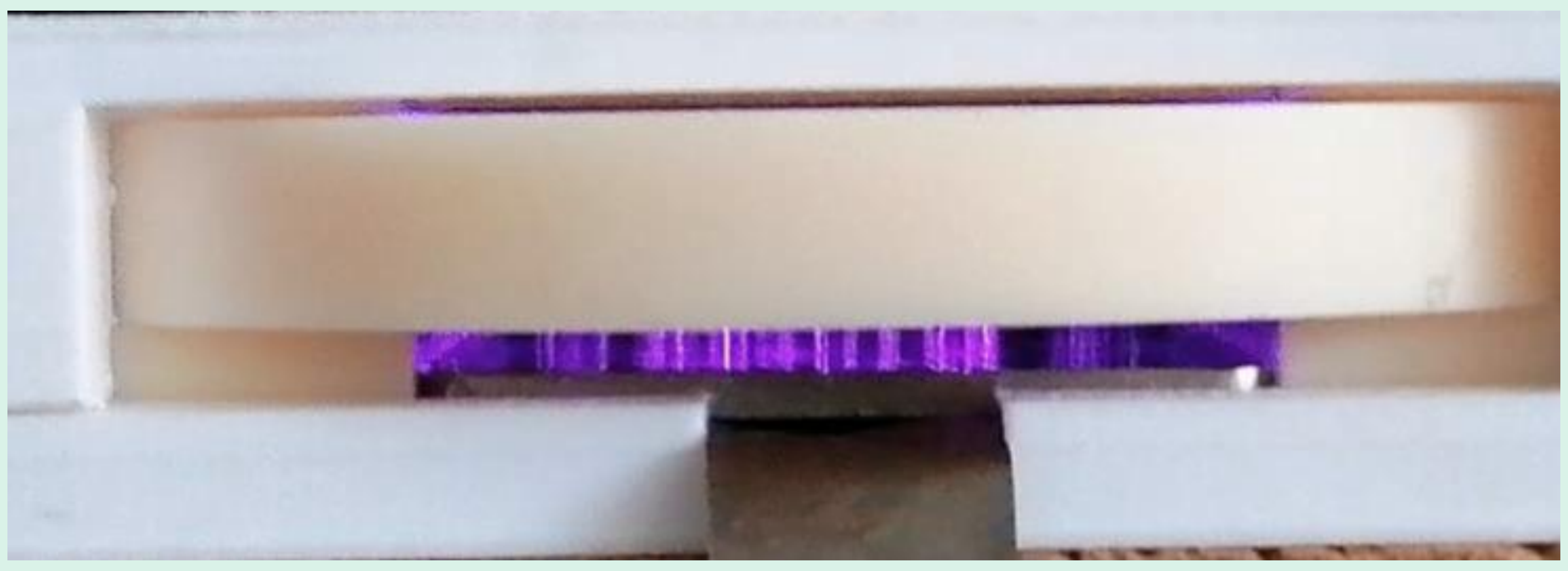

Figure 1 : In-house atmospheric DBD-plasma reactor for the treatment of flat solid samples. The sample is placed on the metallic electrode. The ceramic dielectric barrier is placed just under the opposite electrode on the top of the picture.

b) Reactor(s) for gaseous, liquid and powder samples

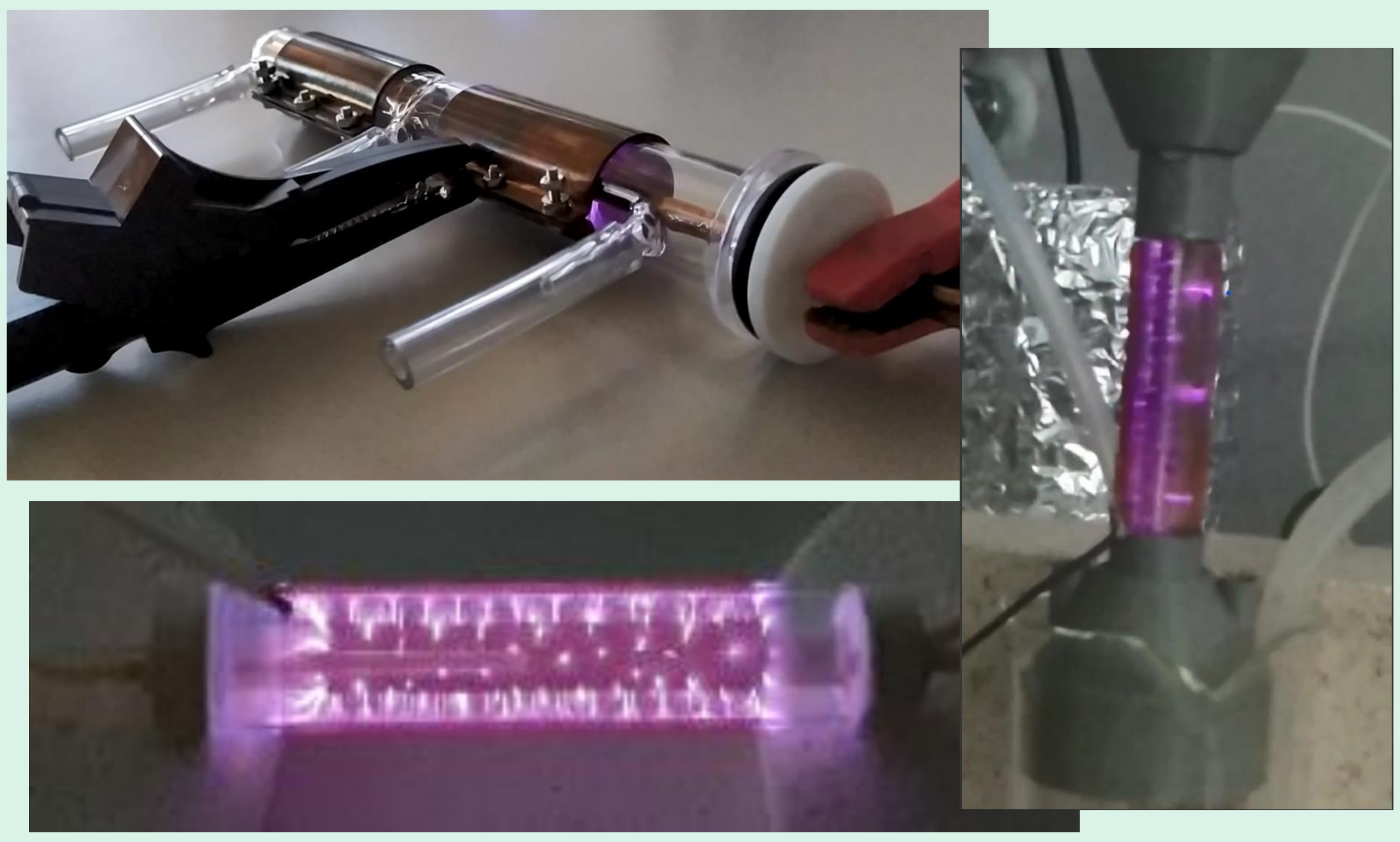

Figure 2: This tubular reactor (bottom, left) can be modified to treat two gases (top left) but also liquid samples as falling film (left) as well as powders using pressurised gases for their transport.

Results & Discussion

Modelling is used to optimize the reactor´s dimensions and the flow field, so that dead volume is avoided and the kinetics as well as the yield are maximized. The optimization has benn proven in the CO_2 conversion in a tubular DBD plasma reactor. (Figure 3)

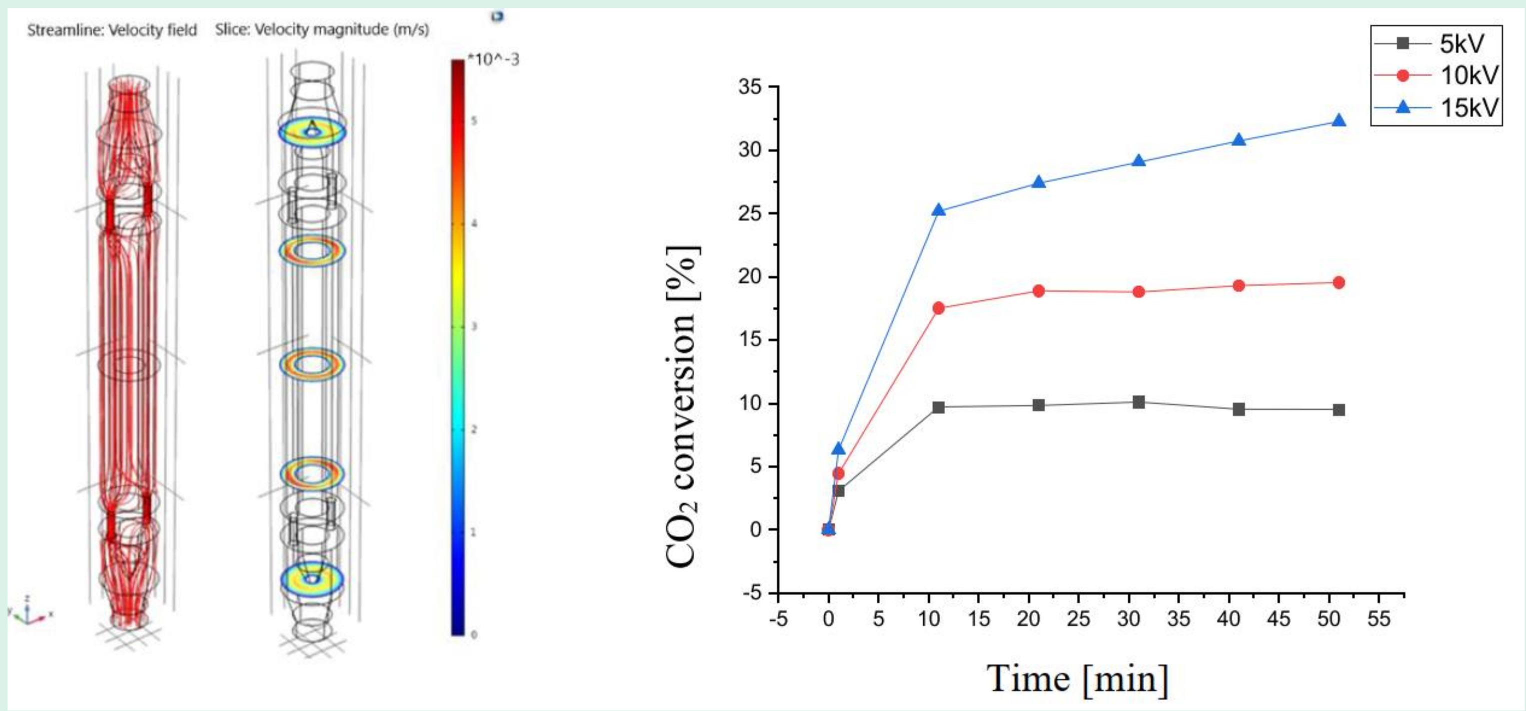

Figure 3: Modell of the flow field in a plasma reactor (left) with catalyst and CO_2 conversion as a function of time and plasma power

The optimised reactor has been used for the degradation of the environmental harmful refrigerant gases R-32 and R-125a (Figure 4). The reactor residence time is calculated from 60 - 15 s for flow rates between 50 and 200 ml/min.

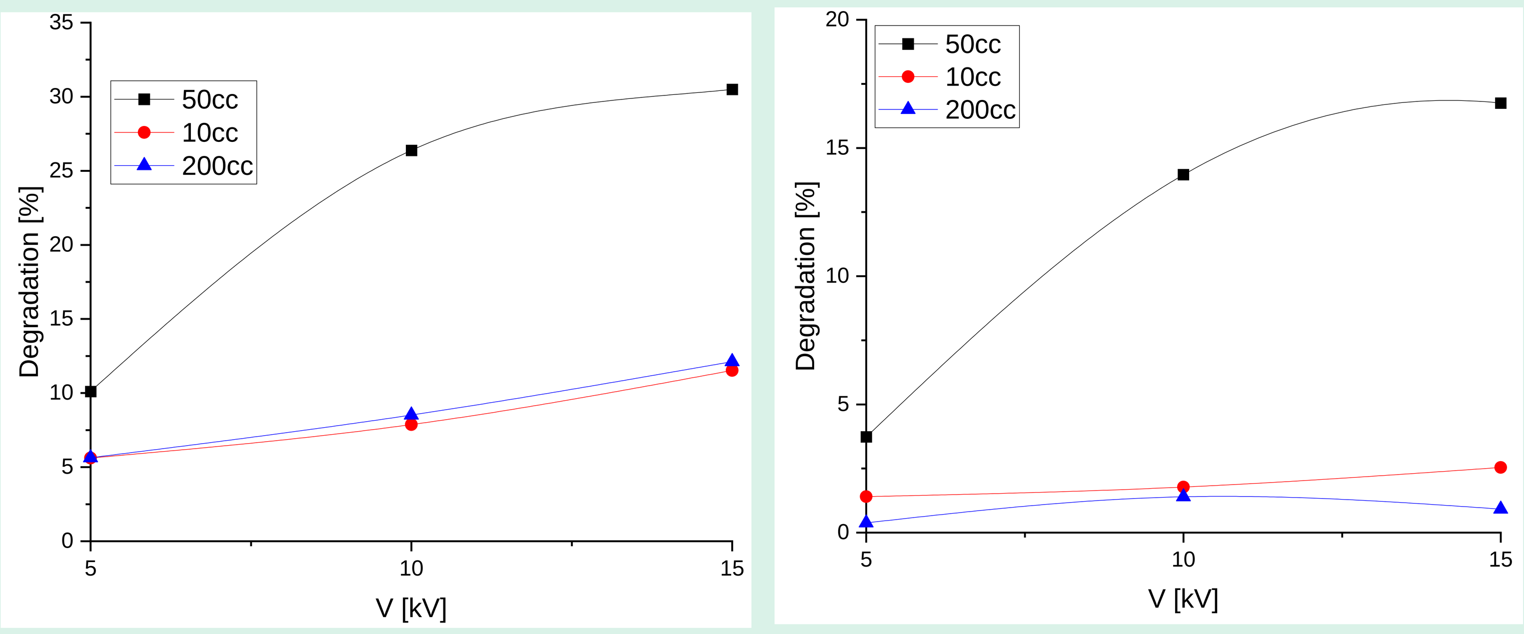

Figure 4: Degradation of R410a components R32 (left) and R125 (right) as a function of applied plasma power and gas concentration (■ 10 %, ● 5%, and ▲ 2.5 %).

Conclusions

Different types of atmospheric (dielectric barrier discharge - DBD) plasma reactors are developed for environmental applications. The possibility to use DBD plasma-based reactors for the degradation of gaseous, liquid and solid (waste) samples has been demonstrated on the example of the degradation of refrigerant gases, which are playing a serious part in the increased global temperature as they contribute to the green-house effect.

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