CO_2 Conversion in a Gliding Arc Discharges with Different Electrode Materials and Magnetic Field Configurations

S. Lazarova, Ts. Paunska, V. Vasilev, St. Kolev(*)

[1] *Faculty of Physics, Sofia University, 5 James Bourchier Boulevard, 1164 Sofia*

(*) skolev@phys.uni-sofia.bg

In this work, the dissociation of CO_2 gas in a gliding arc discharge (GAD) at atmospheric pressure is studied. The discharge device is built in three different configurations, all of them with the classic design with diverging electrodes (Figure 1). The first one employs the configuration of GAD discharge without an external magnetic field. In the other two, magnetic field is applied in a direction perpendicular to the arc current and the gas flow. The field is produced by permanent neodymium magnets. The magnetic field can be oriented in two ways. It can be in a direction, so that the arc is accelerated downstream due to the J×B drift, a case referred to in this paper as Magnetically Accelerated GAD (MAGAD). Alternatively, it can be oriented in a way that slows down the arc, a situation called Magnetically Retarded GAD (MRGAD). The gas flow and the arc are contained in a gas channel, formed between the electrodes and two quartz glasses with a distance between them equal to the electrode thickness, as shown in Figure 1.

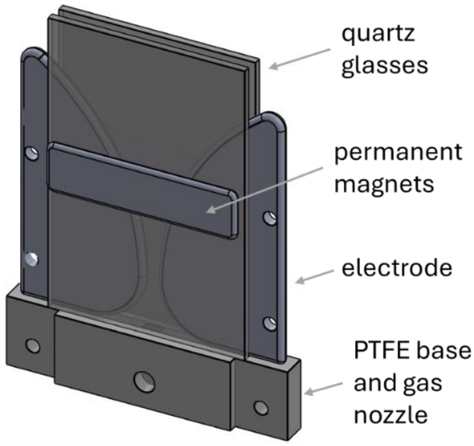

Fig. 1: Schematic 3D view of the discharge configuration including the electrode, the quartz glasses, and the permanent magnets. Note that there is an active cooling system over the quartz glasses which is not shown here.

This study is an extension of a previous work [1] and presents experimental results for the CO_2 dissociation and the energy efficiency for various modifications of the above-described discharge configurations. The applied diagnostic methods are electrical measurements of the arc currents and voltages, as well as Fourier Transform Infrared Spectroscopy (FTIR) for the determination of the outlet gas composition and thus the CO_2 conversion rate. The main differences from the previous study are: 1) the discharges use active cooling on the outer quartz glass walls, in order to improve gas quenching in the afterglow and the discharge stability in long time operation; 2) the distance between the quartz glasses d_{qw} is varied in the range 1 - 4 mm in order to evaluate the effect of this parameter for the CO_2 dissociation; 3) the effect of the electrode material on the CO_2 dissociation performance is also studied for three different electrode materials – stainless steel, copper and aluminium. Similarly to the previous work [1], the discharge is operated at three different current values – 50 mA, 100 mA, 210 mA.

The obtained results show a large variation in the CO_2 conversion rate and energy efficiency depending on the configurations and the current values. With respect to the distance between the quartz glasses, the optimal values are around 2 and 3 mm. At d_{qw} = 1 mm the results are the worst with low energy efficiency and conversion rate.

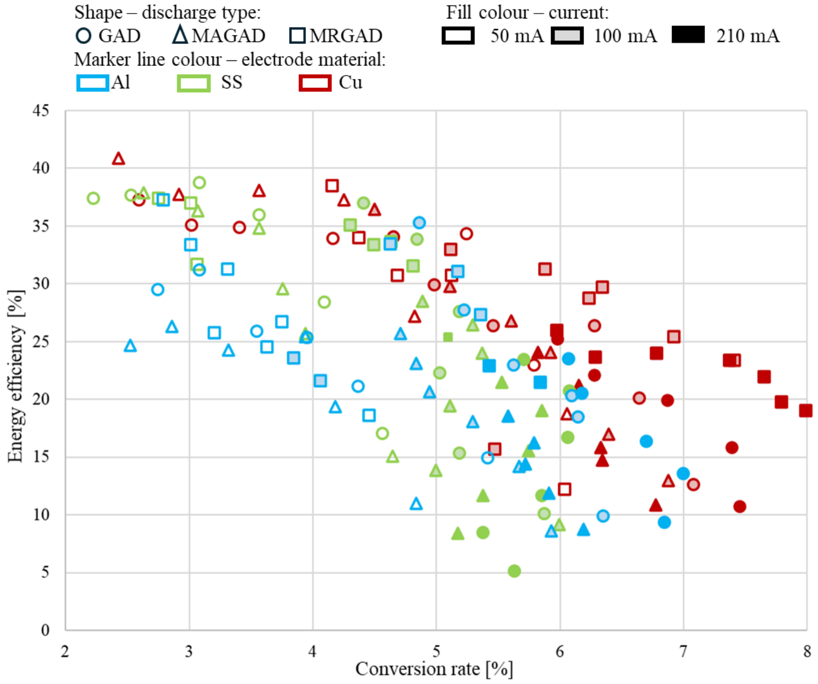

Fig. 2: Plot of the obtained energy efficiency vs the CO_2 conversion rate for d_{qw} = 3 mm for the three different configurations (GAD- circles, MAGAD – triangles, MRGAD - squares) with three different electrode materials (Cu – red symbols, SS – green symbols, Al – blue symbols). The discharge current is presented as the filling rate of the symbols (empty – 50 mA, semi filled – 100 mA, filled – 210 mA).

The effect of the electrode material on the results for d_{qw} = 3 mm is shown in Figure 2. All experimental points are obtained at different gas flow values in the interval 2 - 12 L/min. Overall, the Cu electrodes (the red symbols in Figure 2) show better performance compared to SS and Al with the MRGAD achieving the best combined performance of high conversion rates and energy efficiency. In the case of Al electrodes, the advantage of MRGAD is not so well pronounced and the overall performance is on a par with GAD. In the case of stainless steel electrodes, no configuration has a clear advantage over the other two.

Acknowledgements: This study is financed by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0008-C01.

[1] V. Ivanov, Ts. Paunska, S. Lazarova, A. Bogaerts and St. Kolev, *Journal of CO2 Utilization* **67** (2023) 102300