e development of sustainable and green technologies for the treatment and recovery of resources from wastes is driving a paradigm shi in waste management. Bioenergy production from waste streams can lead to the reduction of pollution, but also decrease the cost of their treatment. Among the new environmental friendly technologies, microbial bioelectrochemical systems (BESs), like microbial fuel cell (MFC) [1] or microbial electrolysis cell (MEC) [2], are considered one of the best alternatives for the sustainable waste treatment of contaminated groundwater [3], wastewater [4] and air polluted streams, and the concomitant production of energy or added value chemicals. [5] One of the critical challenges of these systems is to improve the interaction electrode-microorganism to ensure an e ective transfer of electrons between the solid-state electrode and the biocatalyst. Carbon and graphene materials with various structures, shapes and properties are widely used as electrodes for BES applications due to their high conductivity, good chemical stability and relatively low cost [6,7] However, the performance of BES is o en hindered by low currents and mass transport limitations. A major challenge in this context is an increase in the performance by decreasing the high overpotentials of such systems. Puig et al. [8] identi ed these overportentials as the main energy loss factors (83- 90 % of total losses) in an autotrophic denitri cation in MFCs for waters with low ionic strengths. In this respect, current research is focused on studying the e ects of surface chemistry and the porosity of carbons on their performance in one electrode reaction in BES [9]. e new capabilities of the design, preparations and techniques in material sciences raise the question if BES can bene t from these developments and their performance can be increased further more.

Bio lms on electrode surfaces play a key role in current generation or transformation in BES. By modifying the electrode properties the electronic conductivity, electron transfer and bio lm adhesion can be enhanced. ese modi cations include (1) an increase of the porosity for the most e ective utilization of the surface area [10]; (2) the presence of surface functional groups such as oxygen [11] and nitrogen [12]; (3) an increase of the conductivity and (4) biocompatibility [13]. e surface properties, which include the chemistry and charges present at the electrode surface, have been found to a ect bacterial adhesion, bio lm formation and electron transfer signi cantly [14]. In this regard, one strategy is the improvement of the electrode surface properties by surface treatment procedures such as ammonia treatment, polymer modi cation or surface oxidation [12]. Recent reports have demonstrated an increase in the current density by the presence of oxygen and nitrogen functional groups at the electrode surface of carbon paper or carbon cloth, graphite felt or brush or reticulated vitreous carbons [11,15]. ese surface modi cations are likely to improve bio lm–electrode interactions and thus the rate of electron transfer. Nevertheless, despite numerous studies, the role of the carbon surface features in BES is yet to be clearly established.

A further, promising path is the increase of the active surface area of the electrode material. Substantial current research on porous materials focuses on the development of methods for the generation of functional porous solids with tailored pore structures and pore

area, enhancing the bio lm growth and the current density generated and the high conductivity of the CNTs [17,18].

To provide novel properties, the design of new electrodes combining

References

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9. *XR. &KHQ ;)UHJXLD 6 'RQVH %& 6SRQWDQHRXV PRGL¿FDWLRQ RI FDUERQ VXUIDFH ZLWK QHXWUDO UHG IURP LWV GLD]RQLXP VDOWV IRU ELRHOHFWURFKHPLFDO V\VWHPV %LRVHQVRUV DQG %LRHOHFWURQLFV

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