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FULL PAPER

Advances in electrochemical technologies for sustainable wastewater treatment and chemical synthesis: mechanisms, challenges, and prospects

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In the realm of industrial water reclamation, conventional techniques and advanced oxidation processes (AOPs) often fall short in addressing challenges posed by organic pollutants. Electrochemical technologies are emerging as a promising solution, particularly for the removal of biorefractory substances. This comprehensive review delves into the intricacies of various electrochemical tools for treating wastewater contaminated with organic pollutants. The objectives encompass elucidating fundamental process aspects, exploring the influence of operational parameters and reactor design on performance, critically evaluating pros and cons, and envisioning their practical application potential by identifying key investigatory points. The discussion covers direct electrochemical oxidation, indirect electrochemical oxidation via electrogenerated active chlorine, and the synergy between anodic and cathodic processes. The review also critically assesses reactor options for implementing these technologies. Another aspect addressed pertains to capacitive deionization (CDI), an essential desalination process relying on electrical double layer formation. A subcategory, intercalation capacitive deionization (ICDI), harnesses intercalation materials to achieve desalination through ion insertion into electrode crystal structures upon applying voltage.

KEYWORDS

Electrochemical technologies; wastewater treatment; organic pollutants; electrochemical oxidation; sustainable chemical synthesis.

Introduction

The treatment of wastewater contaminated with organic pollutants poses significant challenges for industries and environmental management due to the limitations of conventional physicochemical and biological methods, as well as the high costs associated with advanced oxidation processes (AOPs) [1]. In this context, electrochemical technologies have emerged as a promising solution for industrial water reclamation, particularly in

addressing the recalcitrant nature of biorefractory substances. This critical review aims to comprehensively explore and evaluate various electrochemical tools for the efficient treatment of organic pollutant-contaminated wastewater. The review focuses on achieving four main objectives: (1) Presenting the fundamental principles underlying the selected electrochemical processes; (2) discussing the influence of key operational parameters and reactor design on process performance; (3) critically assessing the advantages and disadvantages of these methods; and (4) providing insights into the potential scalability of these technologies by identifying areas for further investigation. The current state of the art in wastewater treatment and electrochemical technologies underscores the pressing need for innovative solutions to address the limitations of conventional physicochemical and biological methods, as well as advanced oxidation processes (AOPs). Electrochemical approaches have emerged as a promising avenue for tackling the challenges posed by industrial water reclamation, particularly in dealing with biorefractory pollutants. This critical review aims to shed light on some of the most prospective electrochemical tools for treating wastewater contaminated with organic pollutants [2,3].

By delving into the fundamental aspects of these selected processes and analyzing the influence of key operational parameters and reactor designs on their performance, the review seeks to offer a comprehensive evaluation of their advantages and disadvantages. Furthermore, the study aspires to forecast the practical applicability of these technologies by identifying crucial areas that warrant further exploration. The scope of the review encompasses diverse strategies, such as direct electrochemical oxidation, indirect oxidation mediated by electrogenerated active chlorine, and the synergy between anodic and cathodic processes [4]. A critical assessment of the reactors suitable for implementing these approaches forms the culmination of this review. Through this comprehensive analysis, the review contributes to the ongoing efforts to establish electrochemical technologies as dominant and efficient methods for industrial wastewater treatment, thereby addressing the persistent challenges associated with water pollution and resource scarcity. The novelty and contribution of this research lie in its comprehensive examination of cutting-edge electrochemical technologies as viable solutions for wastewater treatment, particularly targeting the removal of challenging biorefractory pollutants. While conventional methods often fall short in terms of efficiency, cost-effectiveness, and environmental impact, the reviewed electrochemical tools offer promising avenues for addressing these limitations. By presenting an in-depth understanding of the fundamental aspects, operational parameters, and reactor designs that govern the performance of these technologies, the research bridges the gap between theoretical knowledge and practical implementation. Moreover, the identification of advantages and disadvantages, along with critical evaluation of reactors, adds valuable insights for future development and refinement of these approaches [5]-[7]. Ultimately, the research contributes to the broader goal of sustainable water reclamation and pollution control, aligning with the pursuit of efficient solar utilization, green remediation of wastewater, and advanced oxidation processes.

Experimental

Research method

The research methodology employed in this study encompasses a multifaceted approach aimed at comprehensively addressing the challenges and opportunities within the realm of electrochemical technologies for water treatment and chemical synthesis. The preparatory phase involves an in-depth review

of existing physicochemical, biological, and advanced oxidation techniques, highlighting their limitations in industrial water reclamation. Subsequently, a meticulous selection of electrochemical tools, encompassing direct and indirect oxidation, intercalation capacitive deionization (ICDI), protonic ceramic electrochemical cells (PCECs), machine learning simulations, and solubility product determination, forms the basis for detailed investigation [8].

The effects of operational parameters and reactor design on process performance are scrutinized, critically evaluating benefits and drawbacks. Moreover, the review identifies key research gaps and prospective avenues for scalable utilization. By systematically analyzing the interplay between electrochemical processes and fundamental principles, this research methodologically elucidates the potential of electrochemical technologies to redefine sustainable chemical synthesis and wastewater treatment paradigms [9].

Standar and procedure work

The research in question necessitated a rigorous implementation of standards and procedures to ensure methodological rigor and consistency. Standardization encompassed various aspects, including the preparation of experimental setups, data collection, and analysis. To initiate the investigation, well-defined protocols were established for the synthesis and characterization of the target organic pollutants and electrolyte materials. This ensured the reproducibility of starting conditions across experiments. Furthermore, meticulous calibration of measurement instruments, such as potentiostats and voltmeters, was performed to enhance the accuracy of voltage, current, and potential measurements during electrochemical processes [10]

The experimental procedures encompassed a systematic exploration of key operational parameters and reactor configurations. Thus, controlled variations in factors such as electrode material, applied voltage, current density, and flow rates were carried out. Each experimental condition was meticulously documented to facilitate comprehensive analysis and draw meaningful conclusions. Subsequent data analysis involved the application of advanced statistical methods, ensuring robust evaluation of the impact of these parameters on process performance [11].

Moreover, the standardization extended to computational simulations and machine learning approaches. Rigorous validation of simulation methodologies against known experimental data was carried out to ascertain their reliability. The procedures for machine learning model training and validation were also established, ensuring the accurate representation of electrochemical interfaces and reaction kinetics. These standardized practices collectively contributed to the robustness of the research findings, enabling informed interpretations and conclusions to be drawn from the complex interplay of variables within electrochemical systems.

Data collection technique

To gather essential data for this research, a range of data collection techniques will be employed to ensure the accuracy and validity of findings. Experimental data related to the electrochemical performance in various wastewater treatment processes will be collected using calibrated electrochemical devices [12]. Continuous recording of potential, current, and reaction time will be conducted during the electrochemical processes. Additionally, spectroscopic analysis techniques such as FT-IR, UV-Vis, and Fluorescence will be utilized to comprehend structural changes of molecules and the products formed during reactions [13,14]. Sampling and chemical analysis will ensure precise measurement of the concentration and

composition of organic contaminants in wastewater.

Data interpretation techniques

In this research, the interpretation of gathered data will require a multifaceted approach to extract meaningful insights. The complexity of electrochemical processes and the wide array of variables involved necessitate advanced techniques for data interpretation. Statistical analysis methods, such as regression analysis and multivariate data analysis, will be employed to identify correlations, trends, and patterns within the experimental results. These techniques will aid in understanding the relationships between operating parameters, reactor design, and electrochemical performance. Furthermore, computational tools will play a pivotal role in interpreting the acquired data. Molecular simulations and modeling will be used to elucidate the intricate mechanisms occurring at the electrochemical interface. These simulations will provide molecular-level insights into the processes, enabling researchers to validate experimental findings and propose underlying mechanisms. In addition, machine learning algorithms will be utilized to uncover hidden patterns and predict outcomes based on the collected data. These algorithms can assist in identifying key factors that influence performance, which might be challenging to discern through traditional analysis methods [15,16].

Results and discussion

Analysis

The presented research focuses on addressing the limitations of traditional water treatment methods and explores the potential of electrochemical technologies for efficient industrial water reclamation. In this context, Figure 1 illustrates the promotion of reactive species through anodic and cathodic reactions within electrochemical reactors, underlining their diverse applications in water decontamination. The review provides a comprehensive analysis of various electrochemical tools tailored for the treatment of wastewater contaminated with organic pollutants. With the core objectives of elucidating fundamental aspects, assessing operational parameters and reactor design effects, and evaluating advantages and drawbacks, the study sheds light on the promising future role of these technologies in tackling challenging biorefractory substances. By systematically outlining the direct and indirect electrochemical oxidation approaches, as well as the coupling of anodic and cathodic processes, the review establishes a solid foundation for understanding the mechanisms driving efficient pollutant abatement [17].

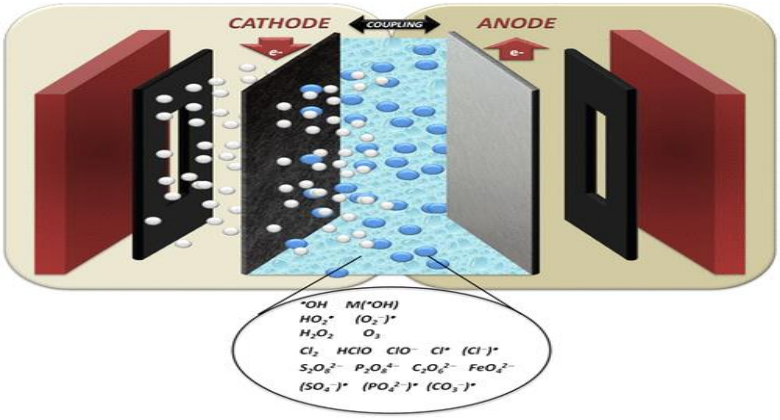

FIGURE 1 The promotion of reactive species by anodic and cathodic reactions within electrochemical reactors offers a wide variety of solutions for water decontamination (https://pubs.acs.org/doi/10.1021/acs.chemrev.5b00361)

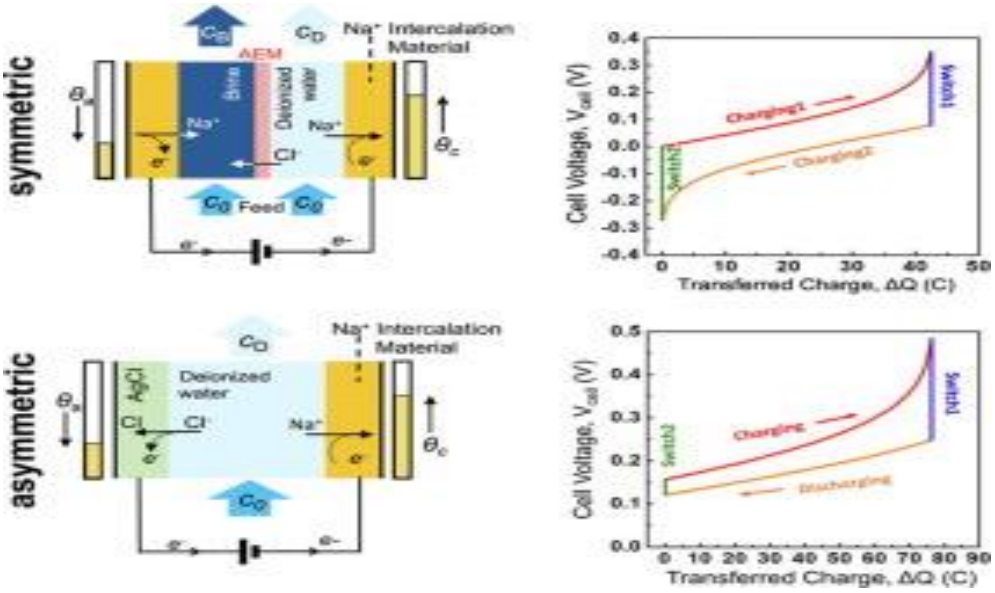

FIGURE 2 Thermodynamic reversible cycles of electrochemical desalination with intercalation materials in symmetric and asymmetric configurations (https://www.sciencedirect.com/science/article/abs/pii/S0021979720304793)

For industrial water reclamation, conventional physicochemical, biological, and advanced oxidation processes (AOPs) are typically insufficient, inefficient, or expensive. In this setting, electrochemical technologies have carved out a distinct niche where they may soon come to dominate, especially in the reduction of biorefractory materials. We explore some of the most promising electrochemical techniques for treating wastewater contaminated with organic contaminants in this in-depth review. Our goals are to: (1) Present the basic ideas underlying the chosen processes; (2) investigate how important operational parameters and reactor design affect their performance; (3) critically evaluate their benefits and drawbacks; and (4) project the potential for their actual application on a larger scale by identifying critical areas [18].

An electrical double layer is created during the desalination process known as conventional capacitive deionization (CDI), which uses carbon electrodes. As opposed to CDI, Intercalation Capacitive Deionization (ICDI), a subset of CDI that uses intercalation materials as electrodes, achieves desalination by introducing ions into the crystal lattice of the electrode upon application of a voltage. Figure 2 illustrates the thermodynamic reversible cycles of electrochemical desalination with intercalation materials in symmetric and asymmetric configurations, offering a deeper understanding of the process. A thermodynamically reversible CDI cycle is always shown to consume electrical work equal to the Gibbs free energy of separation, according to numerical data. A four-stage reversible cycle with both symmetric and asymmetric ICDI underwent thermodynamic analysis. To represent the equilibrium between the electrode and the solution in our investigation, we used the Frumkin isotherm. We provided numerical and analytical evidence proving that the electrical effort necessary to finish [19]. The research also highlights the significance of protonic ceramic electrochemical cells (PCECs) as a versatile technology for power generation, energy storage, and sustainable chemical synthesis.

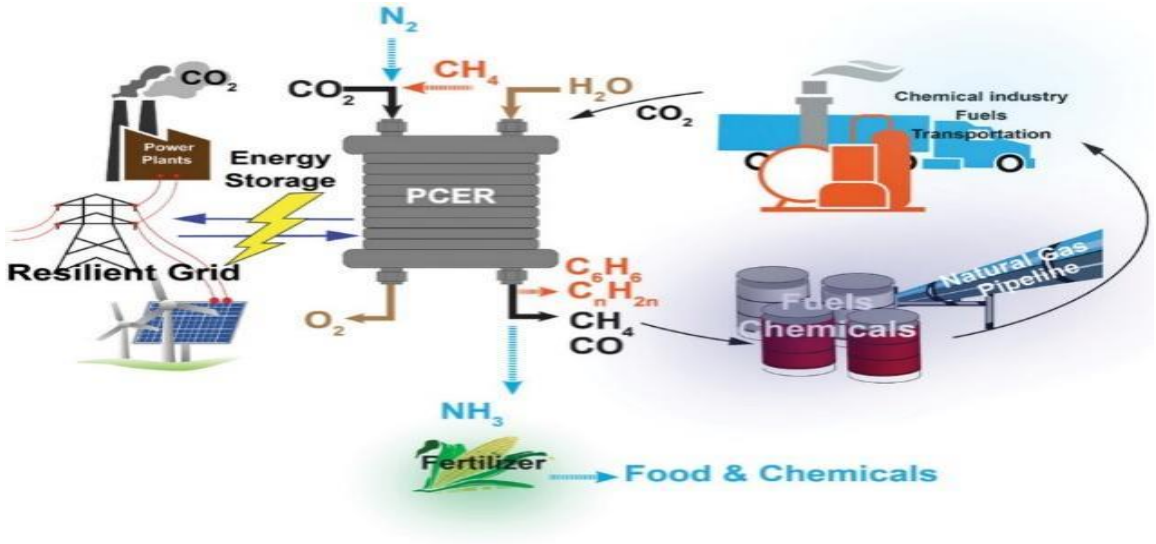

FIGURE 3 Applications of PCECs for sustainable chemical synthesis (https://onlinelibrary.wiley.com/doi/full/10.1002/advs.202206478)

Figure 3 depicts the various applications of PCECs for sustainable chemical synthesis, illustrating their wide-ranging utility in this field. A critical assessment of the recent advancements in electrolyte and electrode materials is provided, aiming to improve the performance of PCECs in chemical production. The analysis underscores the need for a deeper understanding of reactor design, reaction mechanisms, and electrode materials in order to overcome challenges and achieve economically viable chemical synthesis. Through this evaluation, the study emphasizes the potential for PCECs to contribute to the sustainable production of a wide range of chemicals, with a focus on designing electrode materials to optimize product yield and energy efficiency [20].

Power generation, energy storage, and environmentally friendly chemical synthesis are just a few of the areas where protonic ceramic electrochemical cells (PCECs) have attracted a lot of interest. The performance of protonic ceramic fuel cells and electrolyzers has been significantly improved by recent developments in electrolyte and electrode materials. A dearth of thorough knowledge regarding PCEC reactor design, reaction processes, and electrode materials has resulted from the largely ignored development of electrocatalytic materials for chemical synthesis in PCECs. This article thoroughly describes the most recent developments in PCEC-based chemical synthesis, including ammonia, carbon monoxide, methane, light olefins, and aromatics [20]-[21].

The discussion also looks at how conversion rates, selectivity, product yields, and energy efficiencies are affected, providing novel insights into the design of electrochemical cells, the development of electrode materials, and commercially viable chemical processes. Furthermore, the research explores the integration of machine learning methods in simulating electrochemical interfaces, as depicted in Figure 4, which focuses on the recent progress and challenges in machine learning assisted simulations of these interfaces. By addressing the limitations of current models, the study outlines the prospects of employing machine learning to enhance precision and efficiency in studying complex electrocatalytic reactions. The emerging technique offers a novel approach to capture kinetic characteristics that are challenging to explore through traditional methods. By highlighting the significance of accurately describing electrostatic interactions

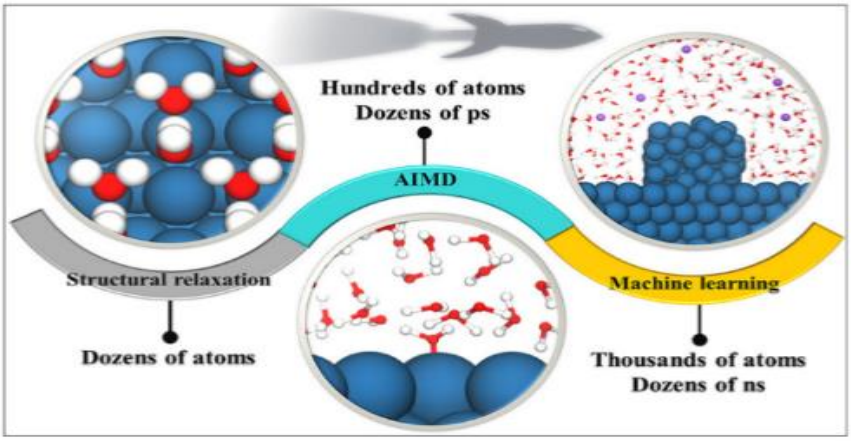

FIGURE 4 Machine learning assisted simulations of electrochemical interfaces: recent progress and challenges (https://pubs.acs.org/doi/10.1021/acs.jpclett.2c03288)

and reaction kinetics, the research paves the way for future advancements in understanding and predicting electrochemical processes.

Reactant adsorption and electrocatalytic reactions take place at the electrochemical interface, which has long attracted considerable interest. Ab initio molecular dynamics simulations are often not able to capture the slow kinetic properties of several of the important activities at this interface. Machine learning techniques have recently come to light as a substitute strategy that allows simulations to span hundreds of atoms and nanosecond time periods while preserving the accuracy and efficiency. In this viewpoint, we give a thorough review of the most recent developments made possible by the use of machine learning to the simulation of electrochemical interfaces. We highlight the existing shortcomings of machine learning models, such as their inability to precisely characterize long-range electrostatic interactions and the kinetics of electrochemical processes at the interface [20].

Interpretation research

The research underscores the shortcomings of conventional water treatment techniques, including physicochemical, biological, and advanced oxidation processes (AOPs), particularly in the context of industrial water reclamation. In response, electrochemical technologies emerge as a promising avenue, especially for addressing biorefractory pollutants. Through a critical review, the study delves into the fundamental aspects of several electrochemical methods tailored to treat wastewater contaminated with organic pollutants [2,3].

It aims to elucidate the intricate interplay between the chosen processes and various operational parameters, reactor designs, advantages, and limitations. Furthermore, the study forecasts the potential applicability of these technologies on an industrial scale, identifying key areas for future investigation. This review focuses on direct electrochemical oxidation, indirect oxidation through electrogenerated active chlorine, and the synergistic coupling of anodic and cathodic processes. Additionally, the research culminates in an assessment of the reactors capable of translating these techniques into practical solutions [23].

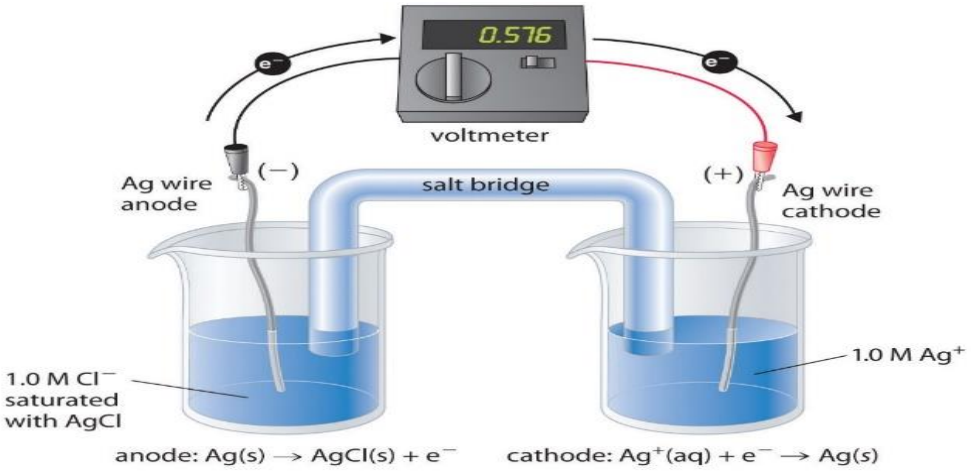

FIGURE 5 A galvanic cell for measuring the solubility product of AgCl (lhttps://2012books.lardbucket.org/books/principles-of-general-chemistry-v1.0/s23-04-electrochemical-cells-and-ther.html)

Due to the accurate determination of voltages possible with a voltmeter, electrochemical techniques provide a handy way to estimate the concentrations of extremely diluted solutions and the solubility products (Ksp) of sparingly soluble compounds. Solubility products can be extremely minute, occasionally dipping below the range of 10-30, as is covered in 'Solubility and Complexation Equilibriums,' in the book. Figure 5 demonstrates a galvanic cell specifically designed for measuring the solubility product of AgCl, showcasing how electrochemical methods can be applied to precisely determine such small equilibrium constants. Equilibrium constants of this scale are nearly impossible to measure with any degree of accuracy using direct approaches, thus more sensitive alternative techniques, like electrochemical ones, must be used.

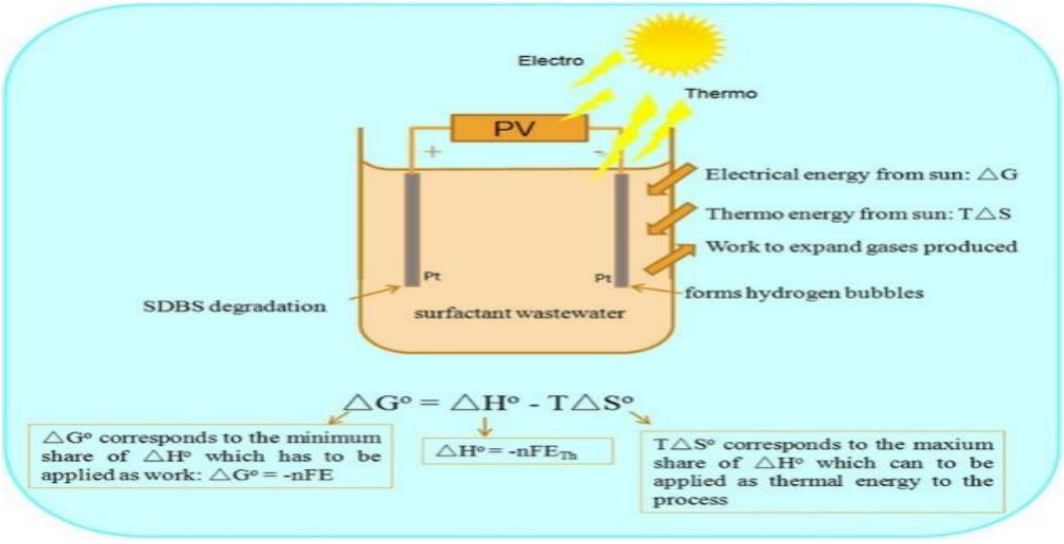

FIGURE 6 Thermodynamics of SDBS degradation (PV is photovoltaic system) (https://www.nature.com/articles/srep44683)

A novel strategy known as solar-mediated thermo-electrochemical oxidation was conceived and developed for the sustainable remediation of surfactant-contaminated wastewater in an effort to address three important research areas: efficient solar utilization, environmentally friendly wastewater remediation, and advanced oxidation processes. The Solar Thermal Electrochemical Process (STEP), a cutting-edge technique, runs purely on solar energy and effectively converts it into both electricity and heat without requiring any external energy sources. In addition to creating hydrogen gas as a useful byproduct, STEP works well for the thermo-electrochemical oxidation of surfactants like SDBS in wastewater. Figure 6 illustrates the thermodynamics of SDBS degradation under the STEP process, highlighting the role of the photovoltaic system (PV) in facilitating this environmentally friendly approach. This technique lowers the effective oxidation potential and lowers the activation energy needed to oxidize electrooxidation-resistant surfactants to CO2 by a combination of thermochemical and electrochemical effects [24].

The study also highlights the realm of capacitive deionization (CDI) and its subcategory, intercalation capacitive deionization (ICDI), as innovative desalination processes. CDI, based on electrical double layer formation, and ICDI, which involves ion insertion into electrode lattice structures upon applying voltage, are explored. The research employs thermodynamic analysis to demonstrate that a four-stage reversible ICDI cycle consumes electrical work equivalent to Gibbs free energy of separation. The symmetry and asymmetry in ICDI are evaluated using Frumkin isotherm to describe electrode-solution equilibrium. This analysis substantiates that ICDI surpasses CDI in energy efficiency when constant voltage charging and discharge processes are employed. Through this lens, the study contributes to understanding the underlying energetics of desalination processes, highlightin the potential advantages of ICDI [19].

In the context of solvation and ion interaction, Figure 7 presents theoretical insights into specific ion effects and strong-weak acid-base rules for ions in solution. It illustrates the derivation of the law of matching solvent affinities from first principles. The

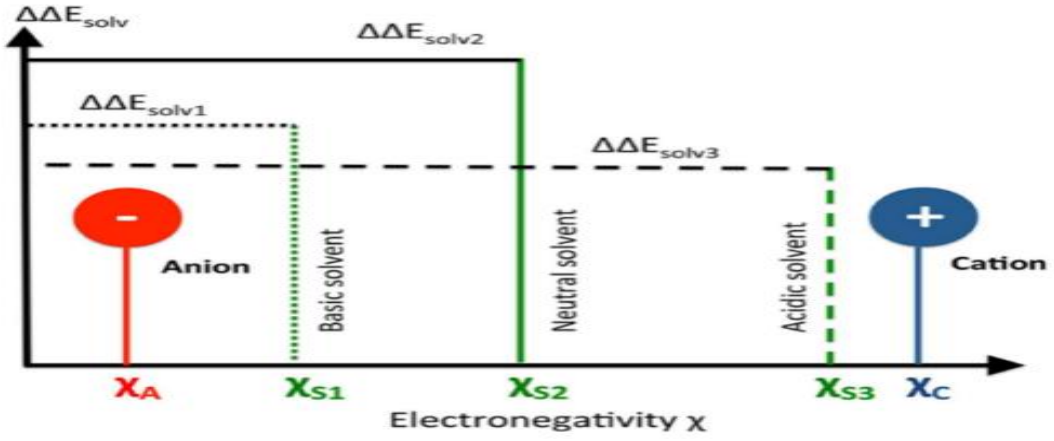

FIGURE 7 Theoretical insights into specific ion effects and strong-weak acid-base rules for ions in solution: deriving the law of matching solvent affinities from first principles (https://www.researchgate.net/figure/Schematic-visualization-of-the-SWAB-principle-For-ion-pairs-with-electronegativities-c-C_fig1_344392772)

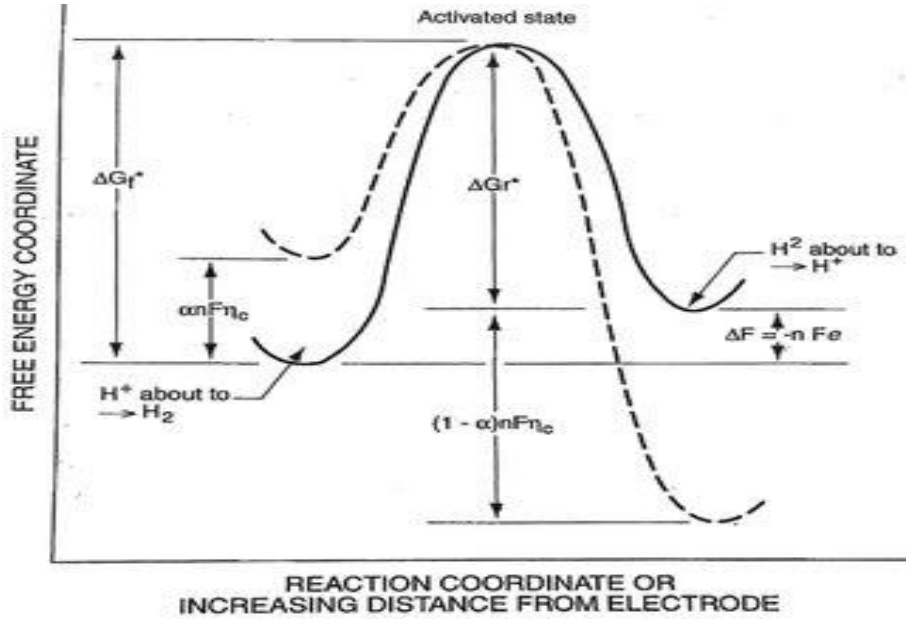

FIGURE 8 Activation energy model for activation overpotential (https://www.researchgate.net/publication/355827282_A_Review_Basics_of_Electrochemical-Thermodynamics_for_FeS_Scale_Formation)

SWAB (Solvation Window for Anion and Cation Binding) principle, which revolves around ion pairs characterized by electronegativities denoted as cC and cA, is schematically illustrated in the text. The principle emphasizes that, under the condition that dC equals dA, where dC is defined as cC minus cS and dA is defined as cS minus cA, in relation to cS2 equaling c max S based on Equation (61), the maximum solvation energy, denoted as DDE solv2, is attained when a neutral solvent with an electronegativity of cS2 is used. Moreover, it clarifies that lower overall solvation energies, known as DDE solv1 and DDE solv3, are produced by basic and acidic solvents with electronegativities cS1 and cS3, respectively, because of different values [25].

The theories and research methods used to explain the thermodynamics and kinetics of acidic corrosion are discussed in this text. It places emphasis on the vital connection between thermodynamics and kinetics, the significance of selecting the proper electrochemical measuring methods, and the use of electrochemistry in steel surface treatments. Understanding the energy changes involved in electrochemical corrosion processes is required by thermodynamics in this situation. The driving force and signs of the spontaneity of a chemical reaction are these energy shifts. Thermodynamics can therefore offer insights into how conditions can be changed to successfully minimize corrosion. Figure 8 provides a visual representation of the activation energy model for activation overpotential, illustrating the critical role this concept plays in understanding the kinetics of electrochemical processes [26].

Furthermore, the investigation emphasizes protonic ceramic electrochemical cells (PCECs) as versatile platforms for power generation, energy storage, and sustainable chemical synthesis. Recent strides in electrolyte and electrode materials are discussed, paving the way for enhanced PCEC performance in chemical production. The review underscores the dearth of systematic insights into reactor design, reaction mechanisms, and electrode materials for synthesizing chemicals in PCECs. The study meticulously examines progress in employing PCECs to synthesize an array of

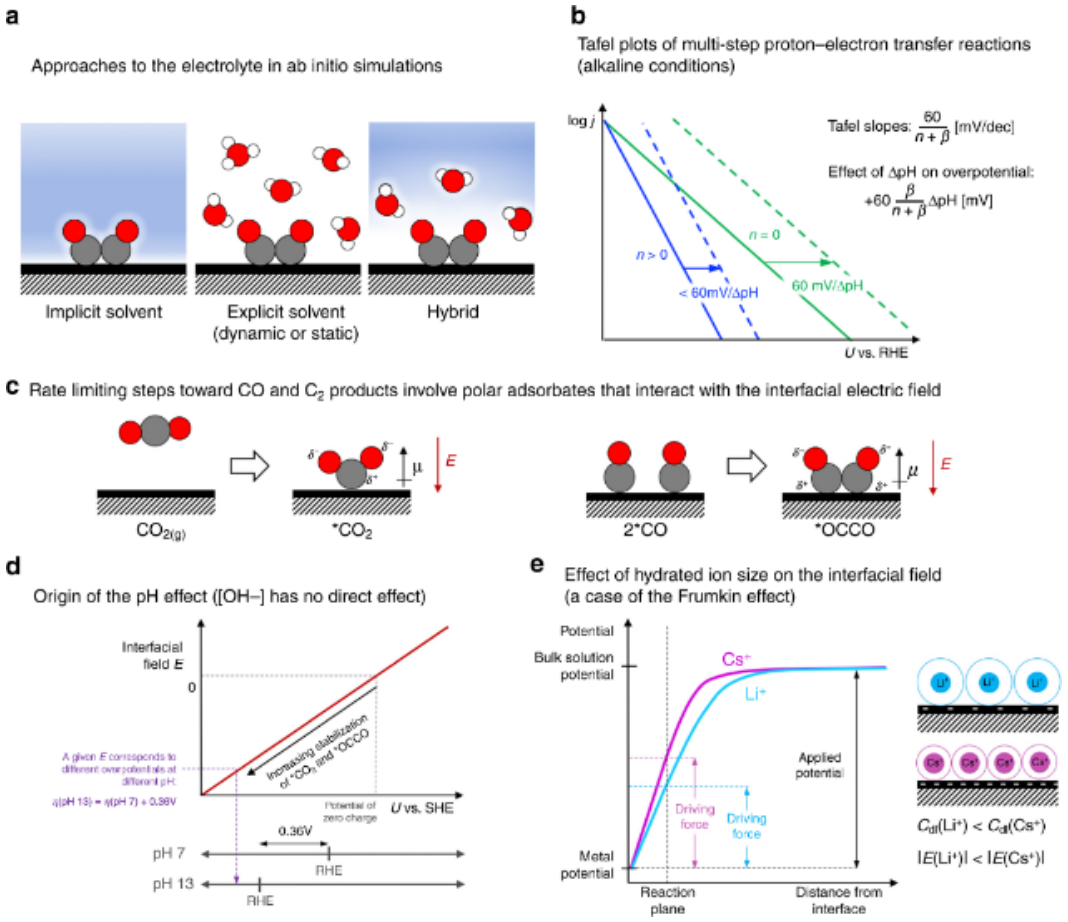

FIGURE 9 Some basic ideas from mechanistic studies of electrochemical carbon dioxide reduction (https://www.nature.com/articles/s41467-020-19369-6)

chemicals, dissecting the factors impacting conversion, selectivity, product yield, and energy efficiencies. Challenges inherent in chemical synthesis using PCECs are outlined, and strategies for overcoming these hurdles, with a focus on designing effective electrode materials, are proposed. This analysis contributes to guiding future research in advancing the synthesis of sustainable chemicals through PCECs [20, 21].

Periodic density functional theory (DFT) simulations have become a potent tool in the field of heterogeneous catalysis, allowing for the computational analysis of reaction processes. The "computational hydrogen electrode" model is our go-to method for determining reaction thermodynamics, specifically for electrocatalysis. This method is unique in that it converts vacuum simulations to potential-dependent energetics without the requirement for explicit simulations of ions or potential, simplifying the computational process [27,28]

Figure 9 presents some basic ideas from mechanistic studies of electrochemical carbon dioxide reduction, providing crucial insights into the methods and challenges of analyzing these reactions. Our models of the electrolyte and electrochemical reaction barriers, in contrast, are far from convergent. Our field abounds with different approaches towards the electrolyte: implicit continuum models, explicit ab initio ones, or a hybrid of the two. We also have multiple ways to obtain the potential and the potential dependence of the reaction energetics. While continuum approximations give us huge reductions in computational cost, we see significant

deviations in solvation energies determined with implicit vs. dynamic explicit water models. Furthermore, different ways to set up the applied potential result in differences in the computed reaction energetics. All these challenges could contribute to the wide range in the computed energetics and mechanisms towards the various C2 products [29].

Comparison

The research provides a comprehensive exploration of electrochemical technologies in the realm of water treatment, emphasizing their potential as a dominant solution for addressing the limitations of traditional methods. With a focus on industrial water reclamation and the mitigation of biorefractory pollutants, the study highlights the strategic goals of presenting fundamental aspects, evaluating operating parameters and reactor designs, critically assessing advantages and disadvantages, and forecasting the practical applicability of these techniques [30]-[31]. By delving into direct and indirect electrochemical oxidation, as well as the coupling of anodic and cathodic processes, the review showcases the promising future of electrochemical methods for wastewater remediation [32].

In synthetic organic electrochemistry, the choice of electrode material is crucial for achieving the highest yields and selectivity. This decision has a significant impact on the kinetics and thermodynamics of electron transport and frequently determines whether a transformation is successful or unsuccessful. Material selection is typically reliant on empirical data due to the intricacy of electrode operations; the underlying mechanisms and causes of success are still unknown [33]-[34]. Figure 10 highlights the importance of 'The choice of electrode material, showing how critical this aspect is in determining the success of electrochemical transformations. Our goal in this analysis is to highlight current instances of electrode material selection where a convincing justification is offered, providing insightful information that can direct future advancements in chemical reactions.

Furthermore, the investigation offers valuable insights into the desalination landscape, particularly in capacitive deionization (CDI) and its intercalation counterpart (ICDI). Through meticulous thermodynamic analysis, the study underscores the efficient energy consumption of ICDI cycles compared to CDI,

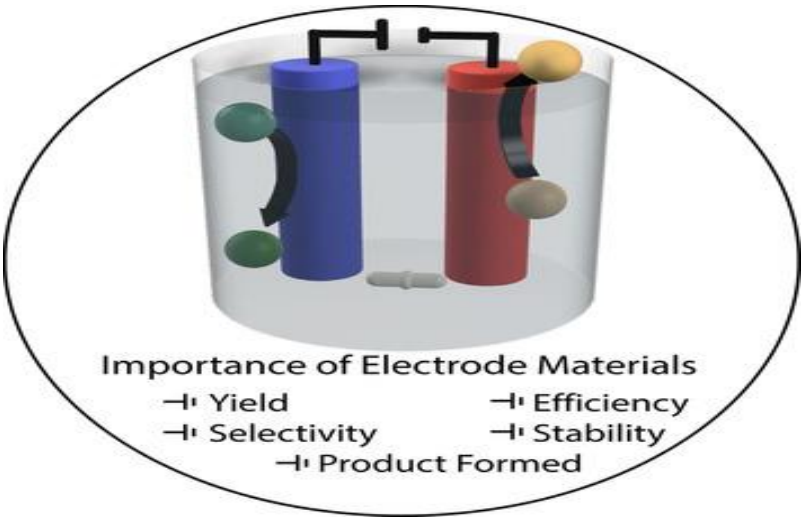

FIGURE 10 The choice of electrode material (https://onlinelibrary.wiley.com/doi/full/10.1002/anie.202005745)

emphasizing the potential advantages of leveraging ion insertion into electrode lattices [35]-[36]. On another front, the study recognizes the pivotal role of protonic ceramic electrochemical cells (PCECs) in sustainable chemical synthesis, power generation, and energy storage. The research highlights the current advancements and challenges in developing efficient electrode materials, aiming for higher product yield and energy efficiency, while shedding light on future directions for achieving viable chemical production in PCECs [37,38] .

Moreover, the research introduces the promising integration of machine learning techniques in simulating electrochemical interfaces. This perspective broadens the horizons of traditional ab initio molecular dynamics, enabling precise and efficient exploration of intricate processes with slow kinetic characteristics [39]. The limitations of current machine learning models are acknowledged, particularly regarding long-range electrostatic interactions and kinetics. As the field advances, the research points towards the potential expansion of machine learning in unraveling complex electrochemical reactions at interfaces [40].

Conclusion

The presented critical review underscores the evolving role of electrochemical technologies in revolutionizing water treatment and various chemical processes. Recognizing the shortcomings of traditional methods and advanced oxidation processes, the research highlights electrochemical approaches as promising solutions for industrial water reclamation, particularly in addressing biorefractory pollutants. The review comprehensively delves into the fundamental aspects, operational parameters, reactor designs, advantages, and drawbacks of these technologies, forecasting their potential applicability on a practical scale. By exploring direct and indirect electrochemical oxidation, intercalation capacitive deionization (ICDI), protonic ceramic electrochemical cells (PCECs), machine learning applications, solubility product determination, and solar-mediated thermo-electrochemical oxidation, the study navigates through diverse dimensions of electrochemical advancements. With an emphasis on energy efficiency, product yield, and selectivity, the research contributes valuable insights to the design of electrochemical cells and materials, offering a glimpse into the promising future of sustainable chemical synthesis and water treatment.

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Conflict of Interest

Authors declares that there is no conflict of interest in this research

Data Availability

The data presented in this research are available on reasonable request from the corresponding author

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