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Removal of Chromium (VI) from Water Using Orange peel as the Biosorbent: Experimental, Modeling, and Kinetic Studies on Adsorption Isotherms and Chemical Structure

Amel Khalfaoui ¹ , Abderrezzaq Benalia ^{1,2} , Zineb Selama ¹, Amira Hammoud ¹, Kerroum Derbal ³, Antonio Panico ⁴  and Antonio Pizzi ^{5,*} 

- ¹ Laboratoire de l'Ingénierie des Procédés de l'Environnement, Faculty Process Engineering, University of Constantine 3, Ali Mendjeli Nouvelle Ville, Constantine 25000, Algeria; khalfaoui_amel@yahoo.fr (A.K.); benalia.abderrezzaq@gmail.com (A.B.); zineb.salama@gmail.com (Z.S.); hammoud.amira@gmail.com (A.H.);
- ² Department of Physics and Chemistry, Higher Normal School of Constantine, Ali Mendjeli Nouvelle Ville, Constantine 25000, Algeria;
- ³ Laboratory of Process Engineering for Sustainable Development and Health Products (GPDDPS), Department of Process Engineering, National Polytechnic School of Constantine, Constantine 25000, Algeria; derbal_kerroum@yahoo.fr
- ⁴ Department of Engineering, University of Campania L. Vanvitelli, 81031 Aversa, Italy; antonio.panico@unicampania.it
- ⁵ Laboratoire d'Etude et Recherche sur le Matériau Bois (LERMAB), Ecole Nationale Supérieure des Technologies et Industries du Bois (ENSTIB), University of Lorraine, 27 Rue Philippe Seguin, 54000 Epinal, France
- * Correspondence: antonio.pizzi@univ-lorraine.fr

Abstract: The present work aims to assess the effectiveness and efficiency of orange peels as a low-cost biosorbent for removing Cr(VI) from an aqueous solution by the biosorbent process. The orange peels as adsorbent was characterized using different methods, such as FTIR, pH_{pzc}, equilibrium pH, TGA, XRD, SEM, and (BET). The tests were conducted in the batch mode, and the effects of different parameters, such as the pH, dosage of the biosorbent, influent Cr(VI), and time, on the biosorption of Cr(VI) were investigated. The adsorption kinetics proved that a contact time of 90 min resulted in the highest (approximately 97.8%) Cr(VI) removal, with an adsorption capacity of 4.96 mg/g. Moreover, the increase in the biosorbent dosage (from 1 to 10 g/L) resulted in the enhancement in the Cr(VI) removal effectiveness. Moreover, the pH of the solution also affected significantly the effectiveness of the removal. The tests were conducted under acidic pH solution conditions, and the prediction of the pH value at a zero charge (pH_{pzc}) was confirmed experimentally. Furthermore, the results from the batch-mode assays were successfully tested by an experimental design (full factorial design). The biosorption of Cr(VI) on orange peels occurred mostly according to the pseudo-second-order kinetic model and the uptake of Cr(VI) was satisfactorily described by the Langmuir model.

Keywords: biosorption; chromium; water treatment; batch mode; kinetic; orange peels



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1. Introduction

Chromium (Cr) is one of the most widely used chemicals in the industry thanks to its valuable effects in processing skin for tannery [1], textiles [2], wood and manufacturing dye [3] as well as in paint and paper [4] and in oil refining [5]. Cr(III) and Cr(VI) are two stable oxidation states of Cr that persist in the environment [6]. Cr (III) is essential for human nutrition, especially in glucose metabolism, while Cr(VI) is toxic for humans, animals, and bacteria. Cr(VI) compounds are known to be carcinogenic [7,8]. According to the World Health Organization (WHO) guidelines, the concentration thresholds of Cr(VI)

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Chemical Reactivity in Confined Systems Pratim Kumar Chattaraj, Debduutta Chakraborty, 2021-08-13 An insightful analysis of confined chemical systems for theoretical and experimental scientists Chemical Reactivity in Confined Systems Theory and Applications presents a theoretical basis for the molecular phenomena observed in confined spaces The book highlights state of the art theoretical and computational approaches with a focus on obtaining physically relevant clarification of the subject to enable the reader to build an appreciation of underlying chemical principles The book includes real world examples of confined systems that highlight how the reactivity of atoms and molecules change upon encapsulation Chapters include discussions on recent developments related to several host guest systems including cucurbit n uril ExBox 4 clathrate hydrates octa acid cavitand metal organic frameworks MOFs covalent organic frameworks COFs zeolites fullerenes and carbon nanotubes Readers will learn how to carry out new calculations to understand the physicochemical behavior of confined quantum systems Topics covered include A thorough introduction to global reactivity descriptors including electronegativity hardness and electrophilicity An exploration of the Fukui function as well as dual descriptors higher order derivatives and reactivity through information theory A practical discussion of spin dependent reactivity and temperature dependent reactivity Concise treatments of population analysis reaction force electron localization functions and the solvent effect on reactivity Perfect for academic researchers and graduate students in theoretical and computational chemistry and confined chemical systems Chemical Reactivity in Confined Systems Theory and Applications will also earn a place in the libraries of professionals working in the areas of catalysis supramolecular chemistry and porous materials *Structure and Reactivity of Coal* Ke-Chang Xie, 2015-06-09 This book provides insights into the development and usage of coal in chemical engineering The reactivity of coal in processes such as pyrolysis gasification liquefaction combustion and swelling is related to its structural properties Using experimental findings and theoretical analysis the book comprehensively answers three crucial issues that are fundamental to the optimization of coal chemical conversions What is the structure of coal How does the underlying structure determine the reactivity of different types of coal How does the structure of coal alter during coal conversion This book will be of interest to both individual readers and institutions involved in teaching and research into chemical engineering and energy conversion technologies It is aimed at advanced level undergraduate students The text is suitable for readers with a basic knowledge of chemistry such as first year undergraduate general science students Higher level students with an in depth understanding of the chemistry of coal will also benefit from the book It will provide a useful reference resource for students and university level teachers as well as practicing engineers **Structure/Reactivity and Thermochemistry of Ions** Pierre Ausloos, Sharon G. Lias, 2012-12-06 This volume presents the proceedings of a 1986 Advanced Study Institute entitled Structure Reactivity and Thermochemistry of Ions held at Les Arcs France June 30 to July 11 1986 The format of a NATO Institute is ideally suited to in depth communications between scientists of diverse

backgrounds Particularly in the field of ion physics and chemistry where on going research involves physicists physical chemists and organic chemists who use a variety of experimental and theoretical techniques it is found that in the relaxed but stimulating atmosphere of a NATO ASI each professional group provides unique insights leading to a better definition and solution of problems relating to the properties of gas phase ions This book presents chapters based on the lectures presented at the Les Arcs ASI The participants took the initiative to organize a number of specialized workshops informal discussion groups which considered questions or problem areas of particular interest The accounts of these sessions which are also included in this book make stimulating reading and include considerable useful information This Advanced Study Institute is the fourth in a series of NATO sponsored institutes devoted to the chemistry and physics of ions in the gas phase The first in 1974 in Biarritz France focussed on Interactions between Ions and Molecules *Chemical Structure and Reactivity* B. R. Eggers, 1972 Strategic Research at the Frontiers of Chemistry, 1995 **Toxicology Research Projects Directory**, 1979 Current Controversies in Diagnostic and Interventional Radiology, An Issue of Radiologic Clinics of North America, E-Book Douglas S. Katz, John J. Hines, 2024-10-15 In this issue of Radiologic Clinics guest editors Drs Douglas S Katz and John J Hines bring their considerable expertise to the topic of Current Evidence for Selected Topics in Diagnostic and Interventional Radiology Current evidence in radiology asks the question what is the most appropriate imaging test on the basis of the best available evidence the physician's experience and the patient's expectations In this issue top experts review current controversies in radiology and the evidence used to support or contradict the clinical question asked Contains 14 relevant practice oriented topics including how do we assess controversies using evidence based radiology artificial intelligence in radiology stroke controversies in imaging intervention and management manufactured controversies have obscured the importance of breast cancer screening nuclear medicine controversies and more Provides in depth clinical reviews on current evidence for selected topics in diagnostic and interventional radiology offering actionable insights for clinical practice Presents the latest information on this timely focused topic under the leadership of experienced editors in the field Authors synthesize and distill the latest research and practice guidelines to create clinically significant topic based reviews *New Frontiers in Nanochemistry: Concepts, Theories, and Trends, 3-Volume Set* Mihai V. Putz, 2022-05-29 New Frontiers in Nanochemistry Concepts Theories and Trends 3 Volume Set explains and explores the important fundamental and advanced modern concepts from various areas of nanochemistry and more broadly the nanosciences This innovative and one of a kind set consists of three volumes that focus on structural nanochemistry topological nanochemistry and sustainable nanochemistry respectively collectively forming an explicative handbook in nanochemistry The compilation provides a rich resource that is both thorough and accessible encompassing the core concepts of multiple areas of nanochemistry It also explores the content through a trans disciplinary lens integrating the basic and advanced modern concepts in nanochemistry with various examples applications issues tools algorithms and even historical notes on the important people from physical

quantum theoretical mathematical and even biological chemistry NMR Studies of Chemical Exchange from Aqueous Metal Clusters Jacqueline Renee Houston, 2006 *Arene Chemistry* Jacques Mortier, 2015-11-30 Organized to enable students and synthetic chemists to understand and expand on aromatic reactions covered in foundation courses the book offers a thorough and accessible mechanistic explanation of aromatic reactions involving arene compounds Surveys methods used for preparing arene compounds and their transformations Connects reactivity and methodology with mechanism Helps readers apply aromatic reactions in a practical context by designing syntheses Provides essential information about techniques used to determine reaction mechanisms New Frontiers in Nanochemistry: Concepts, Theories, and Trends Mihai Putz, 2020-05-10 New Frontiers in Nanochemistry Concepts Theories and Trends Volume 1 Structural Nanochemistry is the first volume of the new three volume set that explains and explores the important concepts from various areas within the nanosciences This first volume focuses on structural nanochemistry and encompasses the general fundamental aspects of nanochemistry while simultaneously incorporating crucial material from other fields in particular mathematic and natural sciences with specific attention to multidisciplinary chemistry Under the broad expertise of the editor the volume contains 50 concise yet comprehensive entries from world renowned scholars alphabetically organizing a multitude of essential basic and advanced concepts ranging from algebraic chemistry to new energy technology from the bondonic theory of chemistry to spintronics and from fractal dimension and kinetics to quantum dots and tight binding and much more The entries contain definitions short characterizations uses and usefulness limitations references and more **Research Grants Index** National Institutes of Health (U.S.). Division of Research Grants, 1975 Modern Physical Organic Chemistry Eric V. Anslyn, Dennis A. Dougherty, 2006 Making explicit the connections between physical organic chemistry and critical fields such as organometallic chemistry materials chemistry bioorganic chemistry and biochemistry this book escorts the reader into an area that has been thoroughly updated in recent times **Effects of Electric Fields on Structure and Reactivity** Sason Shaik, Thijs Stuyver, 2021-03-05 Electric field mediated chemistry is an emerging topic that is rapidly growing and fanning out in many directions It involves theoretical and experimental aspects as well as intense interplay between them including breakthrough achievements such as the proof of principle that a Diels Alder reaction which involves two simultaneous C C bond making events can be catalysed or inhibited simply by changing the direction of an oriented external electric field OEEF This productive interplay between the theoretical and experimental branches of chemistry is continuing and gradually defining a new sub field wherein various sources of electric fields whether external or built in and designed or even surface induced fields plasmons are brought to bear on chemical reactions molecular structures and nano systems leading to control of reactivity selectivity chirality molecular orientations changes in structure and in dynamics Written by leaders in the field Effects of Electric Fields on Structure and Reactivity is the first book on this exciting topic Starting with an overview of the theory behind and demonstrations of the effect of electric fields on structure and reactivity this accessible reference work

aims to encourage those new to the field to consider harnessing these effects in their own work Covering applications and recent theoretical developments it is a useful resource for theoretical chemists and experimentalists alike Environmental Health Perspectives ,1993 **Energy Research Abstracts** ,1993 Semiannual with semiannual and annual indexes References to all scientific and technical literature coming from DOE its laboratories energy centers and contractors Includes all works deriving from DOE other related government sponsored information and foreign nonnuclear information Arranged under 39 categories e g Biomedical sciences basic studies Biomedical sciences applied studies Health and safety and Fusion energy Entry gives bibliographical information and abstract Corporate author subject report number indexes **Electronic Structure and Reactivity of Metal Surfaces** E. Derouane,2013-03-09 Imagine that a young physicist would approach a granting agency and propose to contribute to heterogeneous catalysis by studying the heat conductivity of gases in contact with a hot filament How would he be received now How would he have been treated sixty years ago Yet more than sixty years ago Irving Langmuir through his study of heat transfer from a tungsten filament uncovered most of the fundamental ideas which are used today by the scientific community in pure and applied heterogeneous catalysis Through his work with what were for the first time clean metal surfaces Langmuir formulated during a period of a little over ten years until the early thirties the concepts of chemisorption monolayer adsorption sites adsorption isotherm sticking probability catalytic mechanisms by way of the interaction between chemisorbed species behavior of non uniform surfaces and repulsion between adsorbed dipoles It is fair to say that many of these ideas constituting the first revolution in surface chemistry have since been refined through thousands of investigations Countless papers have been published on the subject of the Langmuir adsorption isotherm the Langmuir catalytic kinetics and the Langmuir site exclusion adsorption kinetics The refinements have been significant The original concepts in their primitive or amended form are used everyday by catalytic chemists and chemical engineers all over the world in their treatment of experimental data design of reactors or invention of new processes **Energy and Water Development Appropriations for 2010: Dept. of Energy fiscal year 2010 justifications** United States. Congress. House. Committee on Appropriations. Subcommittee on Energy and Water Development,2009 **Research Awards Index** ,1988 Guide to Programs National Science Foundation (U.S.),1997

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