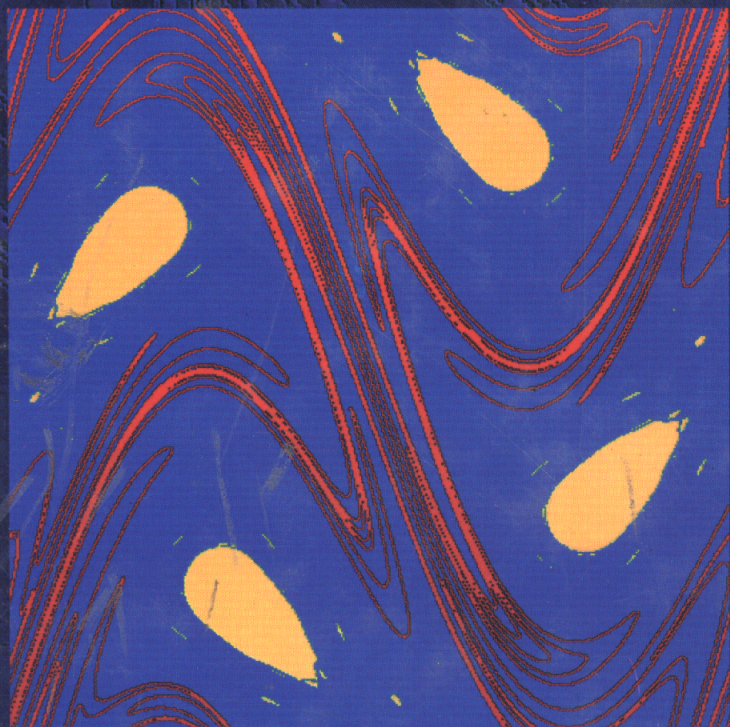


Proceedings of the International CFIC 96 Conference

Fractals and Chaos in Chemical Engineering



editors

**M Giona
G Biardi**

World Scientific

Fractals and Chaos
in
Chemical Engineering



Proceedings of the International CHC '96 Conference

Fractals and Chaos in Chemical Engineering

Rome, Italy

2 - 5 September 1996

editors

M Giona

Università di Cagliari

G Biardi

Politecnico di Milano



World Scientific

Singapore • New Jersey • London • Hong Kong

Published by

World Scientific Publishing Co. Pte. Ltd.

P O Box 128, Farrer Road, Singapore 912805

USA office: Suite 1B, 1060 Main Street, River Edge, NJ 07661

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

1197

FRACTALS AND CHAOS IN CHEMICAL ENGINEERING

Copyright © 1997 by World Scientific Publishing Co. Pte. Ltd.

All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the Publisher.

For photocopying of material in this volume, please pay a copying fee through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA. In this case permission to photocopy is not required from the publisher.

ISBN 981-02-3165-2

Printed in Singapore.

BIBLIOTHEQUE DU CERIST

PREFACE

The CFIC 96 Conference (Rome, September 2-5, 1996) is the second meeting on fractals and chaos and their applications in chemical engineering organized by the Italian Research Center on Disordered Systems and Fractals in Chemical Engineering, jointly founded in 1993 by the Departments of Chemical Engineering of the Universities of Cagliari, Genoa and Rome and the Polytechnic Institute of Milan.

The CFIC 96 Conference was attended by over 100 researchers and students from all countries and all research fields. The original goal of organizing a working conference to facilitate the interdisciplinary exchange of ideas and to address the most relevant applications of dynamical and disordered system theory in reaction engineering, chemical physics and catalysis can, with no undue rhetoric, be described as successfully achieved. The very positive and in some cases enthusiastic response of many participants was the best reward for the great organizational effort involved. Special thanks for making it possible to organize this conference go to the entire group of the University of Rome, and to A.R. Giona, A. Adrover and O. Patierno in particular.

This book contains the articles presented at the conference and accepted for publication after a peer-reviewing procedure. These articles are fully representative of the intense and scientifically rich program of the Conference. The articles are divided into different sections representing the main fields of application of fractal and chaos theory in chemical engineering science.

Special thanks go to the members of the Scientific Committee (P.M. Adler, D. Avnir, F. Brouers, M.-O. Coppens, J. Drahos, R. Krishna, R. Lapasin, F. Muzzio, W. Rudzinski, W.A. Schwalm, T. Vicsek) and to the referees for their cooperation in the preparation of this book. The financial support of the CNR (Consiglio Nazionale delle Ricerche, Comitato per la Chimica) is gratefully acknowledged.

Massimiliano Giona and Giuseppe Biardi
Chairmen of CFIC 96 Conference

CONTENTS

Preface	v
---------------	---

Transport, Reaction, Adsorption in Disordered Systems

The influence of spatial correlations on reaction/diffusion and convective transport phenomena	3
<i>A. Adrover and A. Galassini</i>	
A comparison of reaction rates in mass fractal and nonfractal catalysts	15
<i>M.-O. Coppens and G. F. Froment</i>	
Oxidation processes and fractal properties of activated carbons	27
<i>F. Ehrburger-Dolle, T. Ricker, M.T. Gonzalez, M. Molina-Sabio, F. Rodriguez-Reinoso, P. Pfeifer and P. W. Schmidt</i>	
Transport properties of diluted simple-cubic networks of capillaries	39
<i>S. P. Friedman and N. A. Seaton</i>	
Exact solution of transport schemes in the presence of a multifractal distribution of transport/reaction coefficients	56
<i>M. Giona and A. Adrover</i>	
Perspectives and applications of Green function renormalization with respect to transport phenomena	68
<i>M. Giona, W. A. Schwalm, M. K. Schwalm and A. Adrover</i>	
Adsorption kinetics on fractal surfaces: an approximate mean-field model	80
<i>M. Giustiniani and M. Giona</i>	
Localization of electrons in loopless fractals	91
<i>J. W. Kantelhardt, H. E. Roman and A. Bunde</i>	
Randomness and apparent fractality	103
<i>D. A. Lidar (Hamburger), O. Malcai, O. Biham and D. Avnir</i>	
Electronic structure of the <i>dauidene</i> : the physics of a fractal carbon aggregate ..	115
<i>A. Lorenzoni, H.E. Roman, G. Benedek and R. A. Broglia</i>	
Percolative fragmentation during the gasification of carbons	127
<i>F. Miccio, R. Chirone and P. Salatino</i>	
Fractal characterization of the devil's comb by random walk simulations	139
<i>P. Mougin, M. Pons and J. Villerraux</i>	
Screening transition in diffusion to and across fractal surfaces	151
<i>P. Pfeifer and P. J. Hagerty</i>	
Wavelet analysis for Anderson wavefunctions in one and two dimensions	165
<i>H. E. Roman and J. W. Kantelhardt</i>	
Chaos and correlations in mixed-gas adsorption on the real solid surfaces	175
<i>W. Rudziński and K. Nieszporek</i>	
Diffusion of material and energy on Vicsek and related lattices	187
<i>M. K. Schwalm, D. K. Ludlow and H. Ni</i>	

Group theoretic reduction of discrete diffusion equations on regular fractal structures	199
<i>W. A. Schwalm, M. K. Schwalm and M. Giona</i>	
Immiscible displacement processes in porous media	211
<i>A. M. Vdales, G. Zgrablich, E. N. Miranda and M. Rosen</i>	

Aggregates and Growth Models

Aggregate structure effects from a bimodal primary particle size distribution ..	225
<i>G. C. Bushell, R. Amal and J. A. Raper</i>	
Hydrodynamic drag on suspensions of fractal aggregates	234
<i>D. Coelho, J.-P. Thouvert, R. Thouty and P. M. Adler</i>	
Dynamic scaling of growing surfaces and interfaces	246
<i>F. Family</i>	
Fractal analysis of gap in two-dimensional pattern of silver halide film	286
<i>Y. Hasegawa and S. Miyazima</i>	
Domain wall roughening in disordered media: from local spin dynamics to a continuum description of the interface	293
<i>M. Jost and K. D. Usadel</i>	
Thixotropy in fractal and dense aggregate suspensions	305
<i>R. Lapasin, M. Grassi and S. Prici</i>	
Fractal properties of Eden growth surface with acceleration points	317
<i>T. Nagamine and S. Miyazima</i>	
Diffusion-convection effects in surface decay processes	326
<i>A. P. Reverberi and M. S. Pannagalli</i>	
Cluster structure for off-lattice percolation at criticality	333
<i>H. E. Roman and M. Meyer</i>	
Multifractal analysis of dipmeter well logs for characterization of geological structures	345
<i>A. Saucier, O. K. Huseby and J. Muller</i>	

Turbulence, Mixing and Spatiotemporal Patterns

Scaling properties of tracer trajectories in a three-dimensional saturated porous medium by means of stereoscopic PTV technique	359
<i>A. Cenedese, M. Moroni and P. Viotto</i>	
Scaling gyroscopes cascade: universal multifractal features of 2-d and 3-d turbulence	371
<i>Y. Chigirinskaya, D. Schertzer and S. Lovejoy</i>	
Characterization of strange attractors in the self-ignition of coal stockpiles	385
<i>G. Continillo, G. Gahero, P. L. Maffettone and S. Crescitelli</i>	
Chaotic dynamics of bubble formation in a pool of liquid	397
<i>J. Drahoš, M. C. Ruzicka, V. Pěnkavová and C. Serio</i>	

Bifurcation analysis of the rigid rod model for nematic polymers in shear flows	409
<i>V. Faraoni, P. L. Maffettone and S. Crescielli</i>	
Predictability of multifractal processes: the case of turbulence	421
<i>D. Marsan, D. Schertzer and S. Lovejoy</i>	
Using concepts from dynamical systems theory to understand and enhance mixing in industrial processes	434
<i>F. J. Muzzio, D. M. Hobbs, D. J. Lambert, C. Wightman and D. Brone</i>	
Reactive chaotic flows	451
<i>F. J. Muzzio and M. Liu</i>	
Multifractal properties of temperature fluctuations in turbulence	464
<i>F. Schmitt, D. Schertzer, S. Lovejoy and Y. Brunet</i>	
Fluctuation-dominated kinetics under regular and turbulent flows	476
<i>I. M. Sokolov, R. Reigada, F. Sagués, J. M. Sancho and A. Blumen</i>	

Reactor Dynamics and Chaos

Periodicity and aperiodicity in externally forced industrial FCC units	489
<i>A. E. Abasaheed and S.S.E.H. Elnashaie</i>	
Chaotic behavior of a non-isothermal fluidized bed catalytic reactor under conventional PID control	500
<i>A. Ajbar, K. Alhumaizi and S.S.E.H. Elnashaie</i>	
Neural networks for prediction and control of chaotic fluidized bed hydrodynamics: a first step	512
<i>R. Bakker, R. J. De Korte, J.C. Schouten and C.M. Van den Bleek</i>	
Multidimensional mapping representation by multiple 1-dimensional decomposition for complex systems modelling	518
<i>R. Carotenuto, L. Franchina and M. Coli</i>	
Bifurcation and its implications on industrial UNIPOL process for the production of polyethylene in fluidized bed catalytic reactors	530
<i>S.S.E.H. Elnashaie, N. M. Ghasem and R. Hughes</i>	
Discrete adaptive control of oscillatory and chaotic systems	542
<i>A. L. Fradkov, P. Yu. Guzenko, S. A. Kulushkin and A. V. Osipov</i>	
Gradient control of one and two dimensional discrete time systems	554
<i>P. Yu. Guzenko</i>	
Chaotic behavior of a pseudo-homogeneous flow model of a bioreactor	566
<i>G. Ibrahim and A. Ajbar</i>	
The dynamics of equation solving	578
<i>A. Lucia and D. Liu</i>	
Chaos in systems with chemical reaction - mass transport interactions	590
<i>M. Marek, P. Hasal, I. Schreiber and A. F. Münster</i>	
Adaptive synchronization of coupled chaotic systems	628
<i>A. Yu. Markov and A. L. Fradkov</i>	

A Monte Carlo method for the stability analysis of an ideal PI controlled CSTR performing a ν -order exothermic reaction	640
<i>M. Ratto and O. Paladino</i>	
Nonlinear dynamics of a fixed bed reactor with recycle	652
<i>B. O. Recke and S. B. Jorgensen</i>	
The OGY method in the case of a PI controlled CSTR. Part I: comparison of different ways of building up the method	664
<i>C. Tablino Possio, L. Pellegrini, S. Albertoni</i>	
The OGY method in the case of PI controlled CSTR. Part II: effects of noise ..	676
<i>L. Pellegrini, C. Tablino Possio and G. Biardi</i>	
Bifurcation behaviour of industrial fixed bed catalytic reactors for the production of phthalic anhydride	688
<i>K. M. Wagialla and S.S.E.H. Elnashaie</i>	
Subject index	701
Author index	706
List of contributors	709