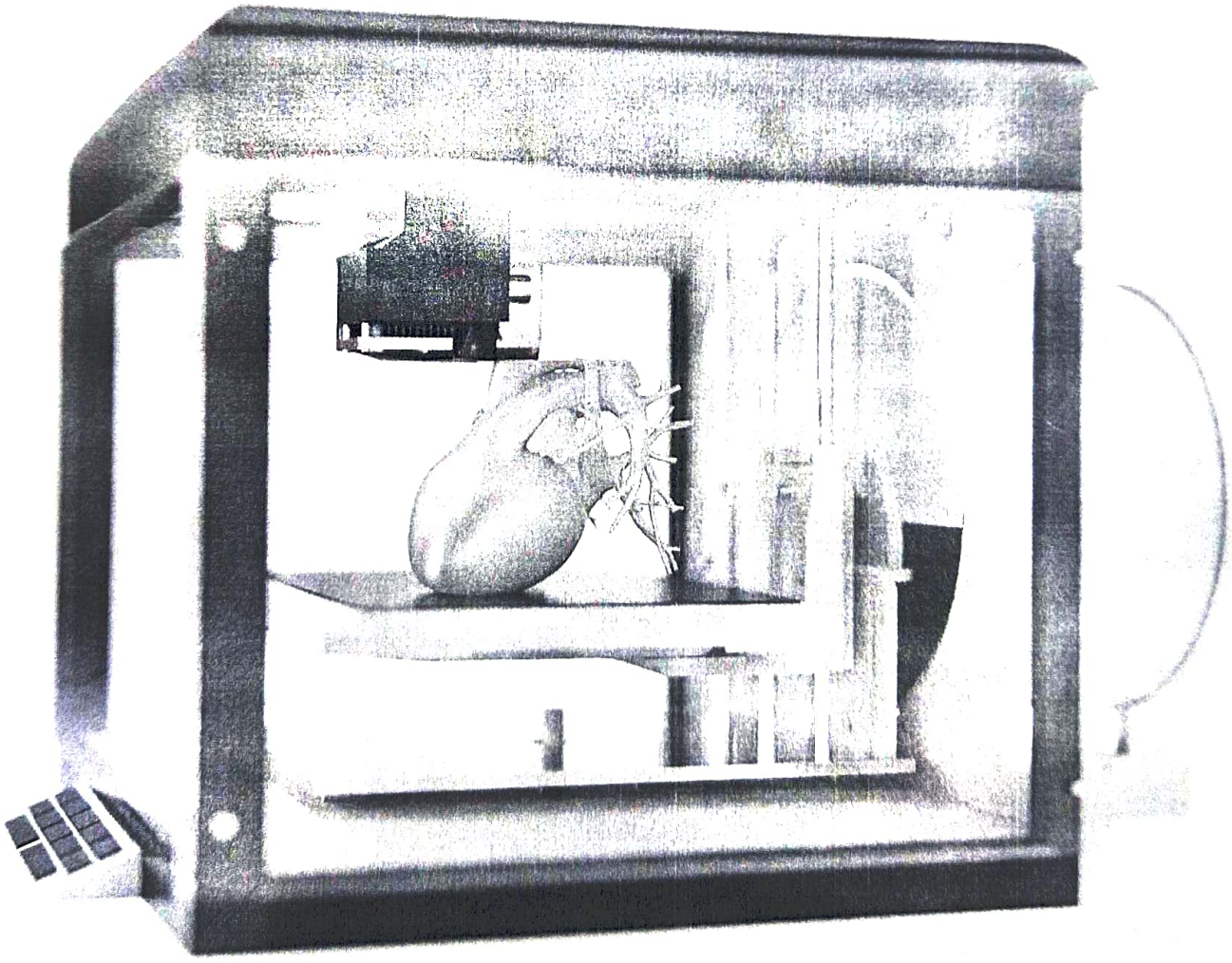
Handbook of 3D Printing in Biomedical Applications

Edited by A.N. Aufa, Mohamad Zaki Hassan, and R.A. Ilyas



CRC Press
Taylor & Francis Group

Designed cover image: Shutterstock

First edition published 2025
by CRC Press
2385 NW Executive Center Drive, Suite 320, Boca Raton FL 33431

and by CRC Press
4 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

CRC Press is an imprint of Taylor & Francis Group, LLC

ISBN: 978-1-032-86069-5 (hbk)
ISBN: 978-1-032-86204-0 (pbk)
ISBN: 978-1-003-52179-2 (ebk)

DOI: 10.1201/9781003521792

Typeset in Times
by Newgen Publishing UK

M.B. Noremylia
Faculty of Artificial Intelligence
Universiti Teknologi Malaysia
Jalan Sultan Yahya Petra, Kuala Lumpur, Malaysia

Maneesha Parmar
School of Pharmacy
Indrashil University
Rajpur, Kadi, Gujarat, India

Gayatri Patel
Ramanbhai Patel College of Pharmacy
Charotar University of Science and Technology
CHARUSAT – Campus
Anand, Gujarat, India

Nisarg Patel
School of Pharmacy
Indrashil University
Rajpur, Kadi, Gujarat, India

Riya M. Patel
School of Pharmacy
Indrashil University
Rajpur, Kadi, Gujarat, India

Dileep Pathote
Department of Materials Engineering
Indian Institute of Science
Bangalore, Karnataka, India

Atanu Kumar Paul
Department of Chemical Engineering
National Institute of Technology Andhra Pradesh
Andhra Pradesh, India

Mohammad Ramzan
Lovely School of Pharmaceutical Sciences
Lovely Professional University
Phagwara, Punjab, India

Brianda Maria Salazar Salas
Departamento de Investigación en Polímeros y Materiales
Universidad de Sonora
Hermosillo, Sonora, Mexico

T. Senthilkumar
Polymeric Materials Area
Chemical and Material Sciences Division
CSIR-Indian Institute of Petroleum
Dehradun, India

Nehal Shah
School of Pharmacy
Indrashil University
Rajpur, Kadi, Gujarat, India

Pratishtha Sharma
School of Pharmacy
Indrashil University
Rajpur, Kadi, Gujarat, India

Saurabh Shukla
Gokul Pharmacy College
Gokul Global University
Siddhpur, Gujarat, India

Larissa Herter Centeno Teixeira
Department of Engineering of Materials and of Bioprocess
School of Chemical Engineering
University of Campinas
Campinas, São Paulo, Brazil

Sneha Thakur
Department of Pharmacognosy
St. Pauls College of Pharmacy
Turkayamjal, Hyderabad, India

Prashant Upadhyay
School of Pharmaceutical Sciences
IFTM University
Moradabad, Uttar Pradesh, India

Contents

1 Fundamental Concepts of Additive Manufacturing in the Biomedical Field

Prashant Upadhyay, Shivani Agarwal, Rahul Chauhan, and Sukirti Upadhyay

1.1 INTRODUCTION

Additive manufacturing (AM) is a modern assembling cycle to create complex three-dimensional (3D) structures by keeping different materials in a layer-by-layer way. In AM, the craft of creation consistently combines with the accuracy of innovation. This innovation has revolutionized numerous modern fields and, as a result, AM has gained recognition in the biomedical field for its potential to transform the medical care sector by revolutionizing the production of clinical devices. AM plays a significant role in advancing the development of patient-specific devices such as muscle inserts and dental restorations. AM uses patient-explicit imaging data from CT, X-ray, or X-beam to make highly customized decisions (Pothala and Raju 2023). For example, 3D printing allows people to make inserts with porous designs that help bones fuse together or break with the surrounding insert, which improves health and long-term success (Mukherjee et al. 2023; Yuan et al. 2019). Moreover, devices can incorporate intricate internal channels to accelerate the flow, a necessary step for enhancing 3D tissue models that include vasculature. These channels likewise support many materials that are biocompatible. AM promotes the use of a diverse range of materials, including polymers, pottery, metals, compounds, biomaterials, and cells. This variety considers the advancement of clinical devices that intently copy or support human tissues and organs. For example, bioprinting (a type of AM process) allows the creation of 3D frameworks made of living cells and organic materials. These frameworks can be used for tissue design, drug screening, and regenerative medicine. Also, innovation considers the consolidation of drugs or development factors into clinical gadgets, empowering limited and controlled drug conveyance (Auriemma et al. 2022). The AM standards had a significant impact on biomedical applications. A few remarkable applications show restraint-explicit inserts, such as muscular inserts for cranial inserts, prosthetics, amplifiers, and dental recreation. It has also grown in careful preparation and execution, with 3D-printed life structure models assisting specialists with imagining testing cases, which improved preoperative preparation and worked on careful results (Thieringer et al. 2022). The future

DOI: 10.1201/9781003521792-1