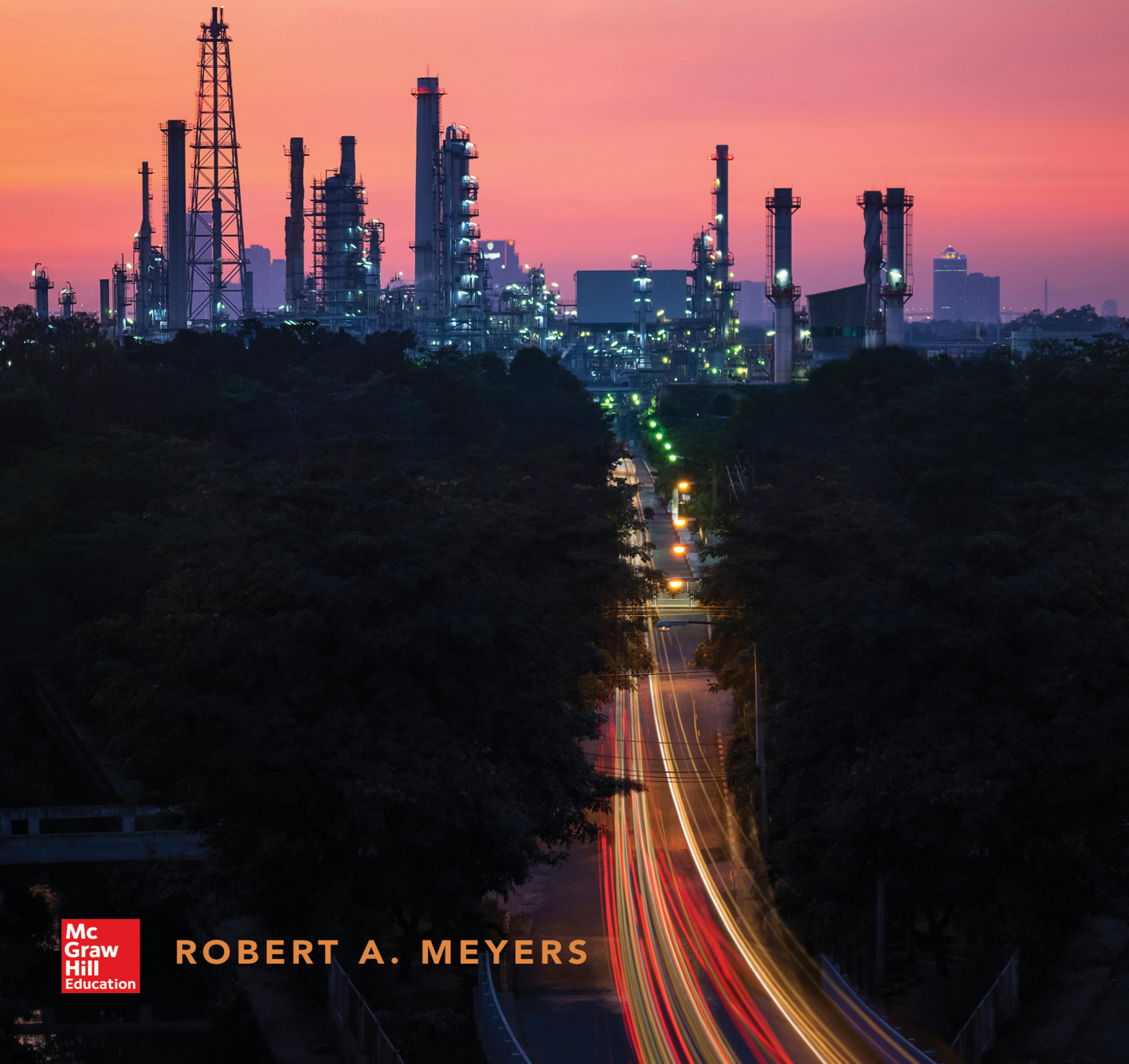
Second Edition

HANDBOOK OF PETROCHEMICALS PRODUCTION PROCESSES



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ROBERT A. MEYERS

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Robert A. Meyers

Second Edition

New York Chicago San Francisco Athens London
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PREFACE

It has been 13 years since publication of the technologies comprising the first edition of the *Handbook of Petrochemicals Production Processes*. This second edition is a complete updating and includes many new technologies and new licensors. This publication is a reference and guide to present-day real-world petrochemicals (intermediates, monomers, and polymers) production methods, product properties, and economics. There is no other single source of such information. The focus is on the most economically important petrochemicals, which together represent a nearly $800 billion market, which is on track to approach $1 trillion by 2024. The Handbook details 57 chemical process technologies that are slated to play a major role in the expansion of petrochemicals production. These are organized into eight product sections:

1. Petrochemical intermediates (cumene, ethylbenzene, xylenes, benzene, toluene, xylenes).
2. Olefins (ethylene, propylene, butene, hexene).
3. Diolefins (butadiene, isoprene).
4. Alcohols and monomers (bisphenol A, butane diol, propane diols, methanol, cumene, and phenol).
5. Acid, ester, and aromatic monomers (styrene, acrylic acid, and acrylates, dimethyl and diphenyl carbonate).
6. Vinyl chloride monomers.
7. Polymers (polyethylenes, polypropylene, polystyrene, polyethylene terephthalate).
8. Methylamines, formaldehyde, and dimethyl ether.

In order to present the global technology base adequately, it was decided to ask the major licensers of the most advanced and utilized licensable technologies to present their processes and economics in a common format suitable for side-by-side comparison. This resulted in a total of 57 technologies presented by 12 of the largest firms in the petrochemicals licensing business. These are Air Liquide, Axens, Badger, BASF, Borealis, CB&I (now McDermott Technology), GTC, Honeywell UOP, Johnson Matthey, Nova Chemicals, Technip (now TechnipFMC), and W.R., Grace, which—together with their licensing partners or technology originators ExxonMobil, BP, Lummus, Versalis, TOTAL, SABIC, Lurgi, TPC Group, and SINCO—represent a large fraction of global petrochemicals production. Contact information for the 12 presenting firms is given within the licenser contacts listing to follow this preface.

The information presented in this Handbook allows engineers to make a first evaluation of licensable processes for new production and provides the basis for engineering students to perform class exercises in the comparison of technologies, environmental factors, and economics for today's most used processes. This comparison provides a set of real world solutions that engineers and students need for their further evaluations.

Each technology licenser was asked to follow the chapter format below in so far as possible:

Handbook Technology Presentations Specification

1. *General process description.* Feed definition and product yield and a simplified flow diagram.
2. *Process chemistry and thermodynamics*. For each major processing unit as applicable.
3. *Process perspective.* Developers, location, and specification of all test and commercial plants and near-term and long-term plans.

4. *Detailed process description.* Process flow diagram with mass and energy balances for major process variations, and feeds and details on unique or key equipment.
5. *Product and by product specifications.* Detailed analyses of all process products and by-products as a function of processing variation and feeds.
6. *Wastes and emissions.* Process solid, liquid, and gas wastes and emissions as a function of processing variation and feeds.
7. *Process economics.* Installed capital cost by major section, total capital investment, operating costs, annualized capital costs with the basis, and price range for each product if applicable.

This Handbook is a companion to the fourth edition of the *Handbook of Petroleum Refining Processes*. That Handbook, in the same format, consists of 54 licenser technology chapters for the processing of petroleum to gasoline and other fuels and products. The two handbooks, together, provide a comprehensive set of technologies for converting crude oil to fuels, intermediates, commodity chemicals, and the major plastics.

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P · A · R · T · 1

INTERMEDIATES