How to Remove Pollutants and Toxic Materials from Air and Water

A Practical Guide

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FOREWORD

This, the thirty-second volume in our Pollution Technology Review series is a practical book dealing with the removal of pollutants and toxic materials from air and water. Subject entries are arranged in alphabetic sequence. Because of the encyclopedic nature of the book it should prove to be very valuable to all those concerned with the problems of pollution abatement and engineering.

As explained in the introduction, this book is based almost exclusively on U.S. patents with coverage extending to a very late date. Because it supplies technical information in detail, it can also be used as a guide to the U.S. patent literature in this field. By indicating all the information that is significant, and eliminating legal jargon and juristic phraseology, this book presents an advanced, technically oriented review of modern pollutant removal practices as depicted in U.S. patents.

The U.S. patent literature is the largest and most comprehensive collection of technical information in the world. There is more practical, commercial, timely process information assembled here than is available from any other source. The technical information obtained from a patent is extremely reliable and comprehensive; sufficient information must be included to avoid rejection for "insufficient disclosure."

The patent literature covers a substantial amount of information not available in the journal literature. The patent literature is a prime source of basic commercially useful information. This information is overlooked by those who rely primarily on the periodical journal literature. It is realized that there is a lag between a patent application on a new process development and the granting of a patent, but it is felt that this may roughly parallel or even anticipate the lag in putting that development into commercial practice.

Many of these patents are being utilized commercially. Whether used or not, they offer opportunities for technological transfer. Also, a major purpose of this book is to describe the number of technical possibilities available, which may open up profitable areas of research and development. The information contained in this book will allow you to establish a sound background before launching into research in this field.

Advanced composition and production methods developed by Noyes Data are employed to bring our new durably bound books to you in a minimum of time. Special techniques are used to close the gap between "manuscript" and "completed book." Industrial technology is progressing so rapidly that time-honored, conventional typesetting, binding and shipping methods are no longer suitable. We have bypassed the delays in the conventional book publishing cycle and provide the user with an effective and convenient means of reviewing up-to-date information in depth.

15 Reasons Why the U.S. Patent Office Literature Is Important to You —

1. The U.S. patent literature is the largest and most comprehensive collection of technical information in the world. There is more practical commercial process information assembled here than is available from any other source.

2. The technical information obtained from the patent literature is extremely comprehensive; sufficient information must be included to avoid rejection for "insufficient disclosure."

3. The patent literature is a prime source of basic commercially utilizable information. This information is overlooked by those who rely primarily on the periodical journal literature.

4. An important feature of the patent literature is that it can serve to avoid duplication of research and development.

5. Patents, unlike periodical literature, are bound by definition to contain new information, data and ideas.

6. It can serve as a source of new ideas in a different but related field, and may be outside the patent protection offered the original invention.

7. Since claims are narrowly defined, much valuable information is included that may be outside the legal protection afforded by the claims.

8. Patents discuss the difficulties associated with previous research, development or production techniques, and offer a specific method of overcoming problems. This gives clues to current process information that has not been published in periodicals or books.

9. Can aid in process design by providing a selection of alternate techniques. A powerful research and engineering tool.

10. Obtain licenses — many U.S. chemical patents have not been developed commercially.

11. Patents provide an excellent starting point for the next investigator.

12. Frequently, innovations derived from research are first disclosed in the patent literature, prior to coverage in the periodical literature.

13. Patents offer a most valuable method of keeping abreast of latest technologies, serving an individual's own "current awareness" program.

14. Copies of U.S. patents are easily obtained from the U.S. Patent Office at 50¢ a copy.

15. It is a creative source of ideas for those with imagination.

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INTRODUCTION

This book is designed to provide a one-volume ready reference for the handling of toxic materials and other pollutants emerging into the air and water from industrial processes.

The developments are coming so fast that getting this information between the covers of one book is virtually impossible. Hence the present volume supplements and updates the earlier (1973) *Pollutant Removal Handbook* from this same publisher.

This book is based almost entirely on material from U.S. patents dealing with practical environmental control systems. It surveys some 500 patents in the 1973 to 1976 period with exhaustive coverage up to November 1, 1976. Since environmental patents are given priority handling by the U.S. Patent Office, many of these were applied for in late 1975 and even early 1976.

So in this volume we offer broad coverage of timely, practical information. This book is addressed to:

- —the industrialist who wants to and must keep abreast of the latest control techniques
- —the environmental protection or public health official
- —legislators who are contemplating control measures and their advisory staffs
- —the conservationist who is interested in exactly what can be done about the effluents of local factories
- —the manufacturer of pollution control equipment

Since, in the interest of combining comprehensiveness with compactness, all literature references cannot be cited here, the reader is referred to the following companion volumes, also published by Noyes Data Corp, for more detail on specific topics.

Mercury Pollution Control (1971)
Sulfuric Acid Manufacture and Effluent Control (1971)
Environmental Control in the Organic and Petrochemical Industries (1972)
Environmental Control in the Inorganic Chemical Industry (1972)
Detergents and Pollution (1972)
Fine Dust and Particulates Removal (1972)
Pollution Control in the Nonferrous Metals Industry (1972)
Waste Disposal Control in the Fruit and Vegetable Industry (1973)
Pollution Control in the Textile Industry (1973)
Pollution Control and Chemical Recovery in the Pulp and Paper Industry (1973)
Pollutant Removal Handbook (1973)
Pollution Control in the Petroleum Industry (1973)
Pollution Control in the Metal Finishing Industry (1973)
Pollution Control in Meat, Poultry and Seafood Processing (1974)
Pollution Control in the Dairy Industry (1974)
Pollution Detection and Monitoring Handbook (1974)
Pollution Control in the Organic Chemical Industry (1974)
Oil Spill Prevention and Removal Handbook (1974)
Environmental Sources and Emissions Handbook (1975)
Pollution Control in the Plastics and Rubber Industry (1975)
Pollution Control in the Asbestos, Cement, Glass and Mineral Industries (1975)
Resource Recovery and Recycling Handbook of Industrial Wastes (1975)
How to Dispose of Toxic Substances and Industrial Wastes (1976)

ACETONE CYANOHYDRIN

Removal from Water

A process developed by *W. Fries; U.S. Patent 3,984,314; October 5, 1976; assigned to Rohm and Haas Company* relates to the purification of industrial effluents containing cyanide ions, and cyanide precursors like acetone-cyanohydrin. The purification of such effluents is carried out by utilizing a complexing compound followed by treatment with an anion exchange resin and optionally cation exchange resin to remove the cyanide complexes. The cyanide values are recovered from the resin by acid regeneration.

ACID MINE WATERS

See Mining Effluents (U.S. Patent 3,823,081)
See Mining Effluents (U.S. Patent 3,717,073)
See Mining Effluents (U.S. Patent 3,795,609)
See Iron Oxides (U.S. Patent 3,537,966)

ACROLEIN PROCESS EFFLUENTS

The toxicity of alpha,beta-ethylenically unsaturated aldehydes and ketones even in low concentrations to biological treatment systems has been recognized by those skilled in the art. A review article on this problem is presented by V.T. Stack, Jr. in *Industrial and Engineering Chemistry,* Volume 49, No. 5, page 913 (1957). In the manufacture of such compounds, the wastewaters containing these organic substances must be processed at very low concentrations if they are further treated by a biological system. If not, the biomass is in danger of being killed or inhibited to a very low level of activity. This problem is particularly acute in the treatment of wastewaters from the manufacture of acrolein, acrylic acid and acrylic acid esters.

Removal from Water

Although disposal of toxic wastes by injection into a deep well has been used, this is a method of questionable efficiency and is not a long-term solution to the problem. Incineration of toxic wastes is also not economical because such methods are more expensive than biological oxidation and can have adverse environmental consequences. Wastewaters containing alpha,beta-ethylenically unsaturated aldehydes or ketones have been processed in the past by slowly adding the contaminated waters to a waste stream effluent so that the level of toxic component is diluted below that which is detrimental to the biological system. This method suffers from the disadvantage of being slow and inconvenient and

is subject to the danger of at times exceeding the toxic limit of the contaminant, because of metering problems, thereby upsetting the operation of the treatment plant. The required dilution may also involve recycle of previously treated wastewater adding significantly to the hydraulic flow and thus to the cost of the biological treatment plant.

A process developed by *E.R. Lashley, Jr.; U.S. Patent 3,923,648; December 2, 1975; assigned to Union Carbide Corporation* for the disposal of wastewaters containing alpha,beta-ethylenically unsaturated aldehydes or ketones containing 3 to 10 carbons comprises contacting the wastewaters with sufficient base to render the pH of the wastewaters alkaline, maintaining the alkaline wastewaters at a temperature of about 25° to 100°C for at least about 15 minutes and then degrading the wastewater in a biological system containing active biomass.

The method outlined above is particularly preferred for use with wastewaters containing acrolein as the alpha,beta-ethylenically unsaturated aldehyde. It is equally useful for other aldehydes such as methacrylaldehyde, crotonaldehyde, 2,4-hexadienal, 2-ethylcrotonaldehyde, and the like as well as alpha,beta-ethylenically unsaturated ketones such as methyl vinyl ketone, and the like.

ACRYLIC RESIN PROCESS EMISSIONS

Water having organic residues such as acrylics, where the acrylic emulsion constitutes only about 2% or so of the total solution by weight, have been difficult to treat because such a solution does not lend itself to conventional chemical treatment or to conventional drying procedures. There is thus a long felt and extremely urgent need for an efficient and high capacity process for purification of such polluted liquids.

Removal from Water

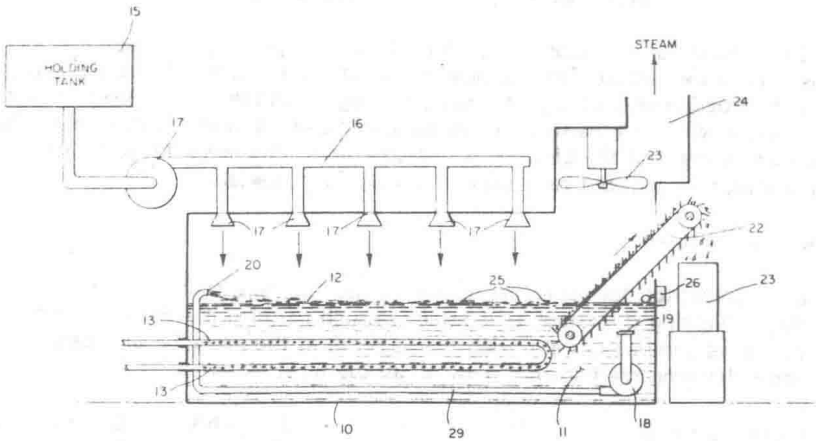
A process developed by *J. Greenberg; U.S. Patent 3,766,087; October 16, 1973; assigned to Anti-Pollution Systems, Inc.* is one in which the polluted water is fed onto the surface of a brine solution maintained at the boiling point, the emulsion being broken instantly at the surface of the brine and accumulated as an organic residue, while the water is boiled off. The organic residue is skimmed off for separate handling.

Such a process is shown in Figure 1. Referring to the drawing, there is shown a container **10** in which is maintained a brine solution **11** having a level **12**. The solution is preferably a concentrated brine solution of water and salt. The process is nonspecific as to the salt, and may be worked with good results with ordinary NaCl, chlorates, nitrates and carbonates. In a preferred example, the brine is a saturated solution of NaCl (39.8% by weight), with some small amount of salt settling at the bottom of container **10**.

A gas fired immersion tube **13** is positioned within container **10** below the brine surface **12**, and provides a source of heating energy to maintain the brine at or just above the boiling level. In the preferred example, the brine solution is maintained at the boiling point, i.e., above 100°C. It is, of course, understood that any suitable means of heating may be employed. The polluted water solution is

fed from a holding tank **15** through a spigot feed **16**, having a plurality of spigots **17** from which the polluted solution is entrained or dropped onto the surface **12** of the brine. A pump **17** is used for transporting the solution into the spigot feed. A second pump **18** takes brine collected from an inlet **19** near the surface **12**, and pumps it through pipe **29** to an ejecting orifice **20** positioned so that the emitted brine pushes the accumulated organic residue (noted at **25**) on the surface **12** from left to right as seen in the drawing.

FIGURE 1: APPARATUS FOR TREATING ACRYLIC RESIN PROCESS WASTEWATERS WITH LOW TEMPERATURE BRINE SOLUTION



Source: U.S. Patent 3,766,087

There is thus, in the figure, a clockwise circulation of the brine, transporting the surface accumulation of organic residue, or scum, toward a conventional skimmer **22** which removes the scum and deposits it into a collection drum **23**. This skimming system is exemplary only, and any type of conventional skimming apparatus and/or system may be utilized which has the function of transporting the scum on the surface to a point where it may be skimmed or otherwise removed into a suitable collection instrument.

In operation, the polluted solution is spread from spigot **17** and distributed substantially uniformly onto the surface **12** of the brine. The brine, which is maintained at the boiling point, causes the emulsion to be broken instantly at the surface, such that it accumulates as organic residue. This effect in breaking the emulsion is also known as salting-out. At the same time that the emulsion is being broken, the water is being boiled off, and is drawn by exhaust fan **23** through port **24** where it is passed into the atmosphere in a safe and substantially pure form. The remaining organic residue, or scum, is pushed and/or drawn toward the skimmer and removed into the collection drum. Since there is about a 5% carryout of the salt with the curdled scum, or organic matter, the salt must be periodically replenished. In practice, the pump **18** and skimmer **22** operate continuously, drawing off the unburned residue. The system has been operated successfully at a rate of pressing 400 gal/hr of polluted water having a 2% emul-