

气雾剂

理论与技术

■ 蒋国民 主编

Aerosol Theory and Technology



化学工业出版社

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· 北京 ·

《气雾剂理论与技术》是气雾剂发展 80 多年来最全面、最系统的一本理论与技术著作。书中几乎囊括了气雾剂的各个方面,对气雾剂发展史与存在的问题,技术理论体系,气雾剂阀门与泵,气雾剂容器,气雾剂抛射剂,气雾剂的生产,气雾剂的安全,各种不同类型气雾剂产品的配方设计原理,配方与配制技术等方面进行了阐述。

该书以 200 多万字的篇幅,详细描述了气雾剂的各个方面,内容翔实、系统,资料丰富、全面,是气雾剂生产者、研究者不可多得的参考资料,可供气雾剂企业技术人员、生产人员、研究人员阅读,也可供精细化工配方研究者、气雾剂阀门与泵设计者等相关人员参考使用。

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自 20 世纪 20 年代末挪威科学家艾立克·罗申发明气雾剂至今已经历了 80 多个年头,世界气雾剂产品达数百品种,年总产量超过了 120 亿罐。其中欧洲约占五分之二,美国约占三分之一多。中国虽然达到第五位,但从人均使用量来算,却位列倒数第六位。

众所周知,气雾剂产品几乎涉及各个领域,它的品种和使用量从一个侧面反映了一个国家经济发达程度及人民的生活质量。

气雾剂是一门多学科交叉,跨行业的应用科学及综合技术,知识涉及范围十分广博,制造工艺复杂多样。

1995 年,我国气雾剂工业发展达到第一阶段高峰期,年产量达到五亿多罐,为 1985 年的十倍,但实际上许多气雾剂企业及技术人员对气雾剂知识及技术方面知道得尚少,十分需要进一步深入了解和提高。此时,复旦大学出版社出版了由上海喷雾与气雾剂研究中心主任蒋国民编著的我国第一本气雾剂专著《气雾剂技术》。1999 年 10 月广州气雾剂展览会上首发的 100 本书,在开幕式后立即被抢购一空,可见业内对气雾剂知识苛求如饥似渴。

美国气雾剂技术权威 M. A. Johnsen 博士称此专著的问世为“中国气雾剂工业日益发展和壮大的又一重要里程碑”。我本人有幸首批得到了这本专著。

这本《气雾剂技术》专著,进一步引导了不少企业及科技人员介入气雾剂行业,为行业的壮大发展奠定了基本的技术理论基础。

1997 年 1 月,国家环保局和中国轻工总会在京召开了十二部委参加的“我国气溶胶行业氯氟化碳物质替代政策研讨会”,并明确气雾剂行业将在当年底全面淘汰氯氟化碳物质的使用。蒋国民高级工程师作为气雾剂专家应邀参加,并在会上做了重要发言。

会后他与我谈起时,心情十分焦急。一方面,禁用期限迫在眉睫,另一方面,替代中的诸多问题还没有很好落实。例如,有些企业虽已在自发地使用易燃易爆丙丁烷混合物替代了氟里昂,但其中存在很多安全隐患,而国内方方面面都对此缺乏清晰的认识;国内还没有一家企业在生产供应规范的替代物——气雾剂级烃类抛射剂;大部分企业没有将灌装作业隔离,且缺少良好的通风;生产储运等操作也很不规范。

抛射剂是气雾剂中一个十分关键的组成,是气雾剂的动力,可比之为气雾剂的心脏,也是气雾剂诞生的基础,对气雾剂的性能起着重要的影响。在使用烃类抛射剂后,易燃易爆安全问题尤为突出。

为此,蒋国民高级工程师一方面约我们一起编著《气雾剂抛射剂手册》,于 1997 年 10 月全面替代 CFC 前夕出版,并组织了气雾剂抛射剂应用技术讲座。另一方面组织气雾剂级烃类抛射剂的开发论证。在他的号召下,中原油田立即响应,投入巨资建成了亚洲最大,年产 5 万吨级气雾剂级烃类抛射剂的生产装置,并在 1998 年 3 月于中原油田现场组织召开了由十个国家部委参加的“气雾剂级烃类抛射剂新产品推广会暨应用技术培训班”。中央电视台、人民日报等多家新闻媒体出席并作报导,规模之盛大,令参加者都为之感动。美国 CPC 公司副总裁 W. A. Framhen 会下对我说:“蒋国民先生为中国气雾剂行业氯氟化碳替代工作所作的努力实在令人钦佩!”

气雾剂阀门是各种气雾剂产品上最关键的组成部分之一,也是气雾剂组成中最复杂,变化最多的一个部件,它的质量状况及与产品是否有良好的匹配,对保证气雾剂产品获得所需喷出图形(或状态)及发挥最佳效能具有十分重要的影响。

蒋国民教授发现国内业界对气雾剂阀门及其应用选择方面认识不足,存在不少误区。为此,他又约我们于 1999 年编写了《气雾剂阀门与泵手册》。

气雾剂中实施氯氟化碳替代后,烃类化合物及二甲醚的易燃易爆安全问题已成为全球的重要议题。联合国环境规划署(UNEP)对此予以高度关注。

2001 年,为了提高我国气雾剂行业在氯氟化碳类物质替代后对安全方面的整体认识和技术,包括运作方面的基础知识、操作技术、安全管理、贮存运输,以及如何防止火灾爆炸事故的发生,确保人身安全及

财产不受损失，我国国家环保总局和国家安全生产监督管理局要求国内气雾剂方面的权威专家和有丰富实践经验的企业家编写气雾剂安全技术方面的图书。

此时，蒋国民教授又提议由我和上海西西艾尔气雾剂推进剂制造与罐装公司总经理李宏硕士为主编写《气雾剂安全技术》。他热忱地为我们提供材料、协助编排，审阅稿件。

作为该书主编的我，虽然《气雾剂安全技术》的问世领先了世界同行一步，国家有关主管领导十分重视，并予题词，但最令我们感动和难忘的是又一次亲身领悟到了蒋国民教授一心为事业，一丝不苟，无私热诚助人的崇高精神。事实上，不少企业要他提供气雾剂产品配方等技术时，他都分文不取，无偿提供。

由于气雾剂产品涉及多学科跨领域的特点，因此，我国政府指定该行业氯氟化碳类物质替代工作，全部由中国轻工总会日化办作为具体职能部门开展，并与联合国环境署联系。但由于人为原因将其误入包装系统，对此业内外大都感到困惑。

真理往往掌握在少数人手里。蒋国民教授从气雾剂产品的属性、用途、安全性（易燃易爆）管理、气雾剂阀门与罐的功能及作用，以及包装的定义及功能全方位作了科学的、客观的阐述，逻辑思维清晰，说服力强。他这种敢于坚持真理的态度，也折射出他对待气雾剂的认真和科学态度。

纵观我国气雾剂工业及卫生杀虫药械行业的发展，每每在关键时刻，蒋国民教授从技术理论方面为行业技术引航。不但自己研究设计，而且及时著书立说供大家参考。

早在20世纪70年代全国“五二三”军工项目需要时，他先后研制成了超低容量喷雾器和静电喷雾器，后者领先了世界一步，获得多项部级及上海市重大科技成果奖。并先后编著了《超低容量喷雾技术》及《静电喷雾技术》两书，还为国内几十个省市植保（总）站及卫生防疫站讲学，足迹遍及全国。

他是原由中国军事医学科学院朱成璞教授为首的中央爱卫会卫生杀虫药械专家组（1978年组建，现为卫生杀虫药械学组）主要创建人之一。为了改变当时家庭喷洒杀虫剂用滴滴涕喷筒的落后局面，1981年他设计了多功能小型塑料喷雾器，现在国内到处都在使用。

1987年，在大家对新崛起的卫生杀虫剂尚不甚了解时，他执笔编著出版了《卫生杀虫药剂、器械与应用指南》，1997年又改编为《卫生杀虫、药剂、器械与应用手册》，成为国内爱卫会、卫生防疫站的主要参考书。

20世纪80年代国内电热蚊香兴起时，他不但亲自设计了电热片蚊香及定时控制电热液体蚊香并获专利，又于1993年编写了世界首本专著《电热蚊香技术》，为电热蚊香的制造和推广奠定了基础。

在2000年，虽然卫生杀虫药剂的推出已近二十年了，但普遍对它没有清晰的认识，概念模糊不清，此时蒋国民教授又及时编写了《卫生杀虫剂剂型技术手册》，在新华书店读者网上被评为五星级图书。在世界卫生组织（WHO）官员推荐下，译成了英文版，广受欢迎。

20世纪90年代末，集装箱熏蒸用甲基溴破坏臭氧层面临被淘汰前夕，他又协助检验检疫系统攻克技术难关，率先研究出一种复配熏蒸剂替代物，并获得了国家发明专利。

在气雾剂领域，他先后对许多气雾剂产品开展了研发设计工作，组织气雾剂级烃类抛射剂的开发论证并号召企业投入生产；在上海组织了（与二甲醚配合使用的）甲缩醛溶剂的生产；国家标准的制订；召开气雾剂技术讲座与交流等。这些都能在本书中见到。

在每个阶段都有他本人亲自研究开发的项目和成果，并及时编写技术图书为振兴行业服务。所以他不仅是一个技术理论家，而且是一个实践家。这些洋洋数百万字的系列技术著作之所以都出自他手，充分反映出蒋国民教授确实是一个具有真才实学、知识渊博，能将他扎实的理论基础与丰富的实践经验相结合的专家。

尤其是四本系列专著，是世界气雾剂领域中唯一的技术文献，连最发达的美国及欧洲都在向他们业内广泛推荐。

蒋国民教授多次应邀出国交流访问，我有幸几次同行，国外同行及我国港台地区对蒋先生的学识和为人的敬重态度令我深为感动。而且外国人邀请都是对方为他全程买单，这不仅仅是钱的问题，更反映出他在世界业内的威望和地位。

蒋国民教授在希腊雅典国际气雾大会上作的报告“水基气雾剂系统及其设计”，符合当前环保发展方向与要求，技术含量的高度与深度，令世人瞩目，国外刊物争相刊登。这是我们中国人第一次登上国际气雾剂领域讲台。

蒋国民教授编著出版的系列气雾剂技术著作及精湛的学术报告，不但为国人争光，也为世界气雾剂工业的发展发挥了不可估量的贡献。

俄罗斯业界评价这些著作“是世界气雾剂领域中珍贵的金矿”，这也许是最精辟的概括。

我国台湾业界知名人士杨锡钦先生 1999 年就称蒋国民教授是“中国气雾剂工业的导师”。在他编著的气雾剂技术著作英文版被全球视为重要文献的今天，我们可以进一步说“他是世界气雾剂工业的导师（尤其是发展中国家）”，一点也不为过，历史会予以证实。

蒋国民教授从事喷雾技术与气雾剂四十年。在他 70 高龄的今天，还在带病为气雾剂行业作锲而不舍的忘我奉献，倾注了大量心血主编完成了这本《气雾剂理论与技术》。他这种敬业精神、严谨的科学态度，一丝不苟的踏实作风，正如中山凯达精细化工公司一位原副总所说，从他的著作的字里行间可以充分领略到蒋教授是一位讲科学，逻辑思维严谨，对读者循循善诱，彻底负责，为人正直的科学家。

业内很多人都知道，蒋教授曾先后推辞了中国轻工总会、中国包装总公司、全国气雾剂阀门开发中心以及中包协主管领导多次邀他出任气雾剂专业委员会副主任等职务。因为对他来说，社会需要就是他义不容辞的责任，他追求的不是什么头衔，也不图虚名，看重的是扎扎实实的为行业办实事，为后人添砖加瓦铺路。正因为如此，国内外业内人士都十分敬重蒋教授的学问和人品。而且热切希望蒋先生组织人员编写内容齐全，范围更广的气雾剂著作。《气雾剂理论与技术》就是在这种背景下，由蒋国民先生组织编写而成的。

本书分十大篇，对气雾剂各个方面作了全面详细的论述，兼顾了科学性与实用性，其内容丰富性是市场上已有的气雾剂方面的书完全不能相比的。特别地，该书首次对全面替代氯氟化碳臭氧损耗物质（氟里昂）后可能出现的安全性，水基型气雾剂，药用气雾剂替代技术等一系列重大难题进行了论述，具有很强的引领性，这是本书的一大特色。该书内容详尽，架构完整，逻辑严密，思想新颖，由浅入深，通俗易懂，特别是利用案例化方法介绍特定产品的开发，既能够激发读者的兴趣，也能够帮助读者很好地体会前几章的理论知识，具有相互呼应的特点，具有很强的实用性，是迄今为止气雾剂领域中最全面系统阐述气雾剂技术理论的专业书籍。

以蒋国民教授为首的我国气雾剂专家和企业编著的这本巨著的问世，填补了世界气雾剂 80 多年来的技术理论体系空白，对国内气雾剂行业是一件喜事。在此，我们祝他老人家身体健康，能把这本巨著翻译成英文版（这项工作除他之外，没有第二个人可担当，无论在技术，还是外语水平方面）也让世界同行得益，对发达国家如此，对发展中国家更如此。

我们深信，这本巨著必将推动我国及世界气雾剂行业规范和健全发展，永载世界气雾剂领域史册，引导世界气雾剂工业向纵深发展。

我国台湾业界龙头企业掌门人黄吉金先生深有感慨的话充分表达了我们两岸同胞的肺腑之言：首先，我想要表达个人由衷发自内心的对蒋国民教授的无比崇敬之意，实在太令我感动了！没想到，中国并非气雾剂的原始开发国家，也无长久的气雾剂生产或研发历史之基础，在最近 30 年才全力投入该行业的国家，先不管目前中国气雾剂之产量是世界第几名（产量高并不表示技术就好），而是竟然有人愿意深入去了解与研究，且深度与广度比欧美日之气雾剂业者长久以来培养与积累经验的技术者还要杰出，这位默默付出，毫不间断地投入与推广，令人不得不敬佩的学者与顶级（最高级）技术工程师就是蒋国民教授，中国气雾剂界应该颁发一项“终生杰出贡献奖”表彰对他至高无上的荣誉奖赏与鼓励才对！

深圳彩虹精细化工有限公司董事长

《气雾剂安全技术》中英文版主编

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It has been eight decades since Norwegian scientist Eric Rotheim invented the first aerosol in the end of 1920s. Up to now, there have been hundreds of varieties of aerosol products in the world with the total output exceeding 12 billion cans. Europe accounts for about 2/5 and US more than 1/3. China has also ranked fifth in this regard, however, it may drop to the sixth from the bottom in terms of per capita consumption.

It is known to all that aerosol is a multi-discipline integrated technology, whose products nearly cover all the sectors and the output and consumption of which can reflect, from one aspect, the level of economic development of a country and the living standard of its people.

Aerosol is a multi-discipline, multi-industry applied science and integrated technology, which involves a broad scope of knowledge and complex and diverse manufacturing technique.

The year 1995 witnessed the peak of the primary stage of the aerosol industry development of our country. Though the nationwide output at that time reached more than 500 million, 10 folds of that of 1985, many aerosol entrepreneurs and technicians still knew little about the knowledge as well as technology, who were in urgent need of a profound understanding and improvement. During that period, the first national aerosol specialized book *Aerosol Technology* written by professor Jiang Guomin, the director of Shanghai Spray and Aerosol Research Center, was published by Fudan University Press, a well-known university in China. It is still fresh in our mind that the first issued 100 volumes in the Guangzhou Aerosol Exhibition in October 1999 were snapped up after the opening ceremony, which clearly showed the strong desire for knowledge of the people in this industry.

US Dr. M. A. Johnsen, the authority on aerosol technology crowned the debut of this specialized book as an important monument of the ever-developing aerosol industry of China. It is a great honor for me to obtain this book among the first group.

This book also further attracted a number of enterprises and technicians to involve in the aerosol industry, thus laying a technological and theoretical foundation for the expansion and development of the industry.

In January 1997, the Bureau of National Environmental Protection and China Light Industry Association held a policy seminar on CFC substitute material of China's aerosol industry with the attendance of 12 ministries and made it clear that CFC material would be gradually eliminated by the end of that year. Professor Jiang was invited to participate in the seminar and made an important speech. He showed a great concern when I talked with him after the seminar. On one hand, time was limited. On the other hand, there still remained many problems concerning substitution. For instance, though people in the circle had spontaneously replaced Freon by flammable and explosive mixture of propane and butane, there still remained a lot of hidden danger which had not been recognized by all the domestic sectors. No domestic enterprises could supply standard substitute-hydrocarbon aerosol propellant. Most enterprises set no isolation for filling gas operations and lacked sound ventilation. Operations of manufacturing, storage and transportation needed to be standardized.

Propellant, a key component of aerosol, serves as a drive, which can be compared to the heart of aerosol. Being the basis of aerosol, propellant has a great impact on the function of aerosol..

In light of this fact, professor Jiang wrote *Aerosol Propellant Handbook*, which was first published in October 1997. In the meantime, he offered lecture on Applied Technology of Aerosol Propellant. Further more, Prof. Jiang devoted himself in the development and demonstration of hydrocarbon aerosol propellant. To answer his call, Zhongyuan Oilfield put huge investment in the establishment of the biggest production plant for hydrocarbon aerosol propellant in Asia with annual output of 50 thousand tons and launched a new product promotion of hydrocarbon aerosol propellant and Applied Technology Training Course on the spot of Zhongyuan Oilfield with the attendance of 10 ministries. Media such as CCTV, People's Daily participated and reported this event and such large scale deeply moved the attendants. W. A. Frannhen, Vice President of CPC company of US, told me that it was really admiring what Prof. Jiang Guomin had done in the work of substitution of CFC material.

Aerosol valve plays the most important part in the aerosol products. Its quality and whether it well matches the product will have a great impact on the shape and state needed as well as guarantee the best function.

Aerosol valve is also the most complex and changeable component of the aerosols, which is composed of up to eight or nine parts.

Prof. Jiang Guomin, professor and senior engineer, aware that the domestic industry lacked the knowledge of the choice and application of aerosol valve and some people still have misunderstandings in this regard. In order to tackle this problem, Prof. Jiang published *Aerosol Valve and Spray Pump Handbook* in 1999.

After the implementation of the policy of CFC substitution, security problems like flammable and explosive hydrocarbons and DME became a worldwide concern, to which UNEP attached great importance. In order to raise the overall awareness of safety and improve the technology, including the basic knowledge, operation skills, safety management, storage, transportation, prevention of fire and explosion, insurance of personal safety and property, State Environmental Protection Administration and State Administration of Work Safety required the domestic authorities and sophisticated entrepreneurs in the aerosol industry to compile some books about aerosol safety.

And Prof. Jiang invited master Li Hong of Shanghai CAL and me to take the lead to write *Aerosol Safety Technology*. During that time, he ardently helped us in the completion of the work in terms of material resources and manuscript review.

Though the birth of it was one step ahead of the world counterparts' and won the focus of the competent authority and obtained inscription, as the chief editor of the book, what most impressed me was the lofty spirit of Prof. Jiang, who was dedicated, meticulous, selfless, warm-hearted and helpful. In fact, he offered product formulation and technology to quite a few enterprises for free.

Truth is often known to minority. As aerosol products involve many disciplines and sectors, the government appointed the Daily chemical products office of China Light Industry Association as functional department in the work of CFC substitution. However, due to human factors and interest motivation. It was divided into packaging system, which perplexed people both in the circle and outside the circle.

Professor Jiang made overall scientific and objective elaboration in terms of the property and purpose of aerosol products, the function and effect of aerosol valves and cans, the security (flammable and explosive) and management of aerosol products as well as the definition and function of package, which was clear in logical thinking and pervasive. His serious and scientific attitude towards aerosol was fully represented in his persistence in truth.

Reviewing the development of the aerosol industry and hygienic insecticides and equipments industry, Prof. Jiang served as a pilot in the industry at every crucial moment. He not only made

efforts in design and research but also marshaled his arguments into books to share with others.

As a matter of fact, professor Jiang also made remarkable contribution to other aspects besides aerosol. Early in the 70s of last century, to meet the needs of the Military Project 523, he developed ultra-low-volume sprayer and electrostatic sprayer one after another. The latter was one step ahead the world, which won many ministerial prizes and was awarded Shanghai significant fruits of scientific research. And Prof. Jiang also compiled two books: *ultra-low-volume sprayer application* and *electrostatic sprayer application*.

Prof. Jiang was also one of the founders of the hygiene and equipment Panel of Central Patriotic Health Committee, which was established by Professor Zhu Chengpu of Military Medical Science Academy. In order to change the backwardness of the Bulun spray-bottle of household spray insecticide, Prof. Jiang timely made a breakthrough to develop the multi-function small plastic sprayer, which is very popular in our society today. And in 1987, he published *the guide of insecticide, equipment and application*, which later became a very important reference book for Central Patriotic Health Committee and Health and epidemic prevention system.

With the rise of the electrical mosquito-repellent incense in 1980s, he designed and patented electric mosquito mat and timing liquid vaporizer. Furthermore, he compiled the world first specialized book *Technology of Electric Vaporizing Mat*, which laid a solid foundation for the manufacturing and promotion of electric vaporizing mat.

In the end of 1990s, because the use of bromide in container fumigation fumigant caused the damage of ozone, it was expected to be eliminated. During that period, he helped the Inspection and quarantine system to overcome technical difficulties and took the lead to develop a substitute mixture of fumigant and got the National Invention Patent.

In the field of aerosol, he had more inventions such as 360° aerosol valve, air-filling aerosol cans, dual-chamber aerosol products, Water-based aerosol insecticide, aircraft cabin insecticide aerosol, Air freshener, lubricant, release agent, shaving cream and personal products. He also made contribution to the development, demonstration, construction and production of hydrocarbon aerosol propellant as well as the formulation of national standard.

We can find his inventions, achievements, specialized books in each stage, which were conducted in person and beneficial to the whole industry. Therefore, he is both a technology theorist and a practitioner. Millions of words in these technological books, his painstaking effort, fully reflected that professor Jiang who could combine his solid theoretical foundation with rich experience and practice was a competent, well-trained and knowledgeable scientist and technical expert.

What's more, he translated four of the specialized books into English, which were highly appreciated by the people of the global industry. As these specialized books were unprecedented in the world history of aerosols, the most developed area like US and Europe regard these four books as the only reference books which could be recommended to the industry and later enjoyed a high popularity.

Professor Jiang have been invited abroad to make international exchanges for many times and I am very honored to accompany for some times. I was moved by our foreign professions and compatriots from Hongkong and Taiwan for their respect to Prof. Jiang's knowledge and behavior. I would like to mention that all the fees were paid by foreign partners, which was not just a matter of money but reflected Prof. Jiang's reputation and status in the industry.

The report, *Water-based aerosol system and its design*, made at the International Aerosol Conference in Athens in Greece was conformed to the current trend and requirement of the aerosol development which was environment-oriented. The advanced technology of it attracted worldwide attention, thus the foreign journals rushed to get it published. This is the first time that Chinese stepped on the international aerosol stage.

The series of Prof. Jiang's aerosol specialized books as well as the excellent academic reports not only won honors for the motherland but also made immeasurable contribution to the world aerosol industry.

The Russian Industry made such comments to these works—the treasure house of the world aerosol industry—it may be the real precious nuggets.

Mr Yang Xiqin, a well-known figure in Taiwan industry, considered Prof. Jiang the guider of China's aerosol industry early in 1999. Then, today, when the English versions of his books are taken as literatures in the world, we have every reason to announce that he is the guider of the world aerosol industry (the developing country in particular), which will be proved by history.

Professor Jiang has been engaging in spray technology and aerosol industry for four decades. Today, the 70-year-old man still works selflessly and persistently for the aerosol industry, who throws all his energy to compile *The Complete Book of aerosol*. As one vice president of Zhongshan Kaida Fine Chemical Co., Ltd. once said we can fully appreciate his devotion to his work, rigorous scientific attitude, meticulous style from reading between lines of his books and Professor Jiang is a responsible and upright scientist with good logical thinking, who is good at giving systematic guidance to readers.

Many people in the industry know that Professor Jiang have declined many positions such as Secretary-General of the National Aerosol Association, Deputy Secretary-General of National Spray Packaging Industry Group, deputy director and chief engineer of Aerosol valves Development Center, The deputy director of the Professional Committee of China packaging association. For him, he has the obligatory responsibility to meet the requirements of the society. What he peruses is neither the title nor the fame, but the substantive work he can do to the industry and to pave the way for the followers. Therefore, the people in the industry, whether domestic or abroad, all show respect to Prof. Jiang's knowledge and personality.

Divided into ten charters, *Aerosol Theory and Technology* gives an overall description on various aspects of aerosol products, which is both scientific and pragmatic. No books on similar subject available can be compared with its rich content. Particularly, this book takes an initial step to explore certain major difficulties such as the possible safety danger after overall Freon substitution, water-based aerosol products and pharmaceutical aerosols substitution technique, whose leading role also serves as one distinctive feature of the book. This book, detailed in content, complete in structure, rigorous in logic and creative in thinking, going from the easy to the difficult, is easy to be understood. It introduces the development of the specified product by raising examples or cases, which can not only arouse the reader's interest but also enable them to digest the theoretical knowledge mentioned in the previous charters. Coherent as it is, the book is of great practicality, which has been so far the most complete specialized book on the technology of world aerosol industry.

The appearance of *Aerosol Theory and Technology*, which was compiled by professor Jiang as the leader and along with other domestic experts, filled the 80-year blank of the technical and theoretical system of the world aerosol industry. It is a joyful event for domestic aerosol industry and the world as a whole, particularly for the developing countries, which brings honor for our people and benefits people all over the world.

We firmly believe that this great book will ever be remembered in the history of world aerosol industry and lead it to in-depth development.

Mr. Huang Jijin, the head of the Leading enterprises in Taiwan island of our country, said from the bottom of his heart: First, I would like to express my personal admiration to Prof. Jiang. It was really moving that China, neither being the cradle of aerosol nor having the historical basis of aerosol production and development, just dipped its finger in the industry 30 years ago but with certain people interested, who are willing to have a deep understanding and re-

search in the industry. The profundity and broadness of the knowledge of those people are better than that of Europe, US and Japan, areas full of well-cultivated and sophisticated technicians. The dedicated scholar as well as top engineer who seeks no rewards for hard labor is no other than Professor Jiang, who compels our admiration. I think he deserves an Outstanding Lifetime Contribution Award by China aerosol industry to have his effort recognized and encouraged. All above gave a full expression of the feeling of the Compatriots on both sides.

By Cheng Yongdi,
Senior Engineer
Chairman of Shenzhen Rainbow Fine Chemical Co., Ltd.
In Shenzhen, April 2010



20 世纪 80 年代末,在中国气雾剂兴起与发展中,由于缺乏气雾剂方面的知识和技术,有的人趁机将从国外得到的配方以数万元高价分别倒卖给多家企业;有的仅一个封口尺寸向企业索要五六千元;有的因为不了解烃类喷射剂的易燃易爆特性而误操作引发了人身伤亡火灾事故;有的还相互争夺技术人员,企业间产生矛盾;对气雾剂阀门及气雾罐与气雾剂内容物之间的匹配关系及如何选择等等不了解,凡此种种,使笔者深深感到国内行业十分需要有一本气雾剂方面的技术书,给行业注入新鲜血液,满足急剧发展的需要,以解燃眉之急。当时笔者本人也正在从事气雾剂开发,对此颇有体会。

气雾剂产品,在一些局外人,或只从表面看来,特别在初入门的人及小企业眼里,似乎很简单,只要买来气雾罐和气雾剂阀门,将根据买到的配方制成的产品料灌入气雾罐内,把气雾剂阀门插入罐内后,再将阀门固定盖在气雾罐上轧紧,然后把当时用的液化气钢瓶倒置灌入气雾罐内,一罐气雾剂产品就制成了。开始时用的氟里昂,不燃;后从降低成本考虑,不少企业自发改用易燃易爆的丙丁烷混合液化气,生产程序及场地也照搬不动,对丙丁烷混合气的易燃易爆危险性缺乏应有的认识。

往往表象简单的事,最容易使人迷惑而失去警觉或重视。

所以,许多人在使用气雾剂产品,但不知道他用的就是气雾剂;许多企业在生产气雾剂产品,或气雾剂的组成物——气雾剂阀门及气雾剂容器(罐),但对气雾剂的知识及技术知道很少,或全然无知。

所有这些,不但严重影响到气雾剂产品的质量及使用性能,而且存在着许多潜在的隐患。在这种形势下,笔者抱着一种将知识和经验系统化的态度,着手编写一本气雾剂技术图书,作为抛砖引玉,供业内参考。

自 1995 年 10 月复旦大学出版第一本《气雾剂技术》以后,令笔者感到欣慰的是,它在当时我国新兴的气雾剂行业中多少发挥了一定的作用。如上海交大毕业后担任上海华新气雾剂公司技术总监的张毅博士,在他导师的推荐下买了这本书,并约见笔者面叙;河北康达精细化工公司的技术副总王学民向笔者坦言,是这本《气雾剂技术》帮他进入了气雾剂大门。凡此种种,对笔者都是一种莫大的鼓励。

之后,笔者又联合国内业界一批技术和企业精英,先后根据行业发展的需要,1997 年在氯氟化碳替代前夕编写了《气雾剂喷射剂手册》;1998 年编写了《气雾剂阀门与泵手册》;2000 年,在国家环保总局与安全生产监督管理局提示下,笔者提议具有丰富经验的深圳彩虹精细化工有限公司陈永弟董事长与上海 CAL 气雾剂推进剂制造与罐装公司李宏总经理(MBA)联手编写了《气雾剂安全技术》;2007 年,受联合国环境规划署及国家环保总局的委托,编写翻译了《气雾剂安全指南》。

期间,在国内外同行的提议下,笔者将已出版的《气雾剂喷射剂手册》、《气雾剂阀门与泵手册》、《家庭及公共卫生用杀虫剂剂型技术手册》中文版及陈永弟、李宏主编的《气雾剂安全技术》中文版,先后翻译成英文版,气雾剂老大美国及欧洲竟然均将我们的技术著作作为他们的头道金牌推向他们的业界。俄罗斯人称“这些著作可称是气雾剂领域中珍贵的金矿”。使高傲的西方同行对我们刮目相看,领受到了我们中国人的实力!这既是我们的自豪,也是对我们的激励!

自第一本《气雾剂技术》出版以来,转瞬已有 15 个年头了。书早已售完不说,这十多年来我国气雾剂行业发生了很大的变化,许多问题需要予以重新认识和审视。在技术理论方面,虽然之前已经先后编写出版了一系列专著,但需要使世界气雾剂工业诞生 80 年来形成一个全面的、完整的技术理论体系,以使整个行业适应新形势的要求和发展。

在这种情况下,根据各方面的要求和希望,笔者联合国内气雾剂方面有真才实学的专家和企业家,在总结以前气雾剂技术著作的基础上,结合我们多年的研究成果与实践经验,加上近年国外同行的新进展,编写本书。

我们尽力使读者在这本新的《气雾剂理论与技术》中找到比金矿更珍贵的钻石,共同为发展我国及世界气雾剂工业携手合作。

众所周知,气雾剂的问世为许多日用化工及医药产品增加了一种全新的剂型。气雾剂产品应用领域面广,生产工艺复杂多样。气雾剂技术是一门涉及众多学科的综合技术;气雾剂容器应用到金属材料、涂料、密封及耐腐蚀材料,涉及材料学、力学、加工工艺学、涂覆及印刷、机械强度设计及测定;气雾剂产品上最关键,最复杂,变化最多的组成部分之一的气雾剂阀门,应用到塑料、橡胶及金属材料,涉及结构设计、精密模具及成型工艺、喷射速率控制及雾化原理、雾滴尺寸的选择及测定、封口及严格的气密性试验,它的质量状况及与产品是否有良好的匹配,对保证气雾剂产品获得所需的喷出图形(或状态)及发挥最佳效能具有十分重要的影响;气雾剂产品料液,要考虑各种有效成分、溶剂和添加剂相互之间的配比及相容性,涉及配方和配制工艺的设计,以及生物学、生态学、毒理学、物理、化学等诸多方面;抛射剂作为气雾剂诞生的基础及动力源,一方面关系着保护臭氧层——人类生存的保护伞不受破坏,另一方面又涉及生产中对化学危险品的安全操作、运送、贮存及废弃物的处置,易燃易爆空气混合物浓度检测、报警及通风,防火防爆紧急事故处理,对人员的各种安全防护,符合各种政府法规、条令的要求;从气雾剂产品的整体性角度来说,它不是上述容器、阀门、抛射剂与产品料液各组成之间的简单相加,而是涉及使用效果、适用性、安全性及经济性诸多方面,要从许多相互制约、相互作用、相互影响的因子中通过一系列实验筛选出优化组合设计,再经调整后做出综合评价,而且还要顾及到符合有关法规,适应消费者及市场的需求。气雾剂的安全问题是一个受到全球性关注的重要议题,它所包含的内容十分广泛,在宏观上涉及对人类生存环境的重大影响,如对臭氧层的损耗,温室效应,人类健康等诸多方面;在微观上关系到局部的火灾爆炸危险,中毒,财产损失及操作或使用者的生命安全及其它。所有这些,都是一个复杂的综合性的系统工程。事实上,无论是应用到的材料和技艺,还是涉及学科及理论,远远不止这些。

将本书取名《气雾剂理论与技术》,一是区别于以前已出版的技术专著,二是本书几乎囊括了气雾剂所有各个方面,从发展史与存在的问题,技术理论体系,气雾剂阀门与泵,气雾剂容器,气雾剂抛射剂,气雾剂的生产,气雾剂的安全,各种不同类型气雾剂产品的配方设计原理,配方与配制技术。

气雾剂中原来一直使用氯氟化碳物质(氟里昂)作为抛射剂,自1976年发现氯氟化碳物质损耗臭氧层后,出于环保要求,需用烃类化合物替代,但替代物易燃易爆的特性引发燃烧爆炸事故导致人员伤亡及财产损失,引起全球关注,为此在第二篇气雾剂的兴起、发展及现状中,全面阐述了替代工作的情况,从十五个方面总结介绍了在我国政府领导下提前完成气雾剂行业规模宏大的氯氟化碳替代工作;承深圳彩虹精细化工有限公司总裁陈永弟高级工程师及上海西西艾尔气雾剂推进剂制造与罐装公司李宏总经理的鼎力支持,以他们主编的《气雾剂安全技术》一书为蓝本编为第七篇气雾剂及其生产企业的安全事故控制;这不但对我国气雾剂行业的健康发展奠定了坚实基础,也为其它国家提供了系统的经验。

药用气雾剂直接用于人体,其中氯氟化碳物质替代难度较高,至今没有系统的材料,在本书第九篇中加入了第八章药用气雾剂,由上海市食品药品监督管理局陈桂良博士执笔撰写。陈桂良博士是我国参与联合国环境规划署药用气雾剂氯氟化碳臭氧损耗物质替代磋商代表。陈博士执笔撰写的这一章详细,全面,系统,填补了国内药用气雾剂技术理论的空白。由于药用气雾剂的特殊性,所以在组成,生产工艺及设备与测试等诸多方面的阐述自成一体,在该章内单独介绍。

第七篇详细介绍气雾剂及其生产企业的的生产安全事故控制。同时为符合环保要求,应在气雾剂中减少挥发性有机物的含量,向水基方向发展,这也是一个全球的难题,为此在编写第九篇气雾剂产品的配方及工艺时,专门加入了第三章CFC替代后水基气雾剂配方设计中的相关问题,为读者提供设计思路;以后对各类气雾剂产品均以水基配方的设计介绍为基础。对国外同行新进展的介绍,在国内业界也鲜为人知,可作借鉴参考。而且在书中有关章节加入了作者的多项研发与设计成果以及亲自参与开展的各项工。

第十篇对各类气雾剂产品常用的主要成分及其功能作一介绍,便于企业在开发气雾剂产品时参考。最后还加入了与气雾剂相关的附录及索引。

在本书编写中,参加协助编排,打印,制图或提供材料的有孙晗,邓先松,赵臻,曾争光,杨宁,杨芍,吴定伟,张媛,谢轶舒等。

这本《气雾剂理论与技术》的工作量是巨大的。在大家的努力和支持下,终于如愿得以付梓出版。因为涉及的内容实在太多,但编者的知识面及实践经验有限,也由于精力、时间及篇幅的限制,有的只能取其要点,有的不得不忍痛割爱,对不大实用的,也就舍去了。虽我们本着“说实话,办实事,求实效”的态度,尽最大努力为社会为行业做点贡献,但其中不乏不妥之处,敬请各方面专家及读者不吝赐教。

在整个编写过程中,得到国家质量监督检验检疫总局、国家标准委、农业部农药鉴定所、环保部、国

家安全生产监督管理局、中国轻工业联合会、中国疾病预防控制中心传染病预防控制所，中国日用杂品工业协会及家庭卫生专业委员会，国家质检总局家用杀虫用品中心，上海市食品药品监督管理局、上海市科委、上海市科学技术协会、上海市轻工科技协会、复旦大学、上海交通大学、上海理工大学、上海（原中国轻工总会）香料研究所、上海市科技咨询服务中心、上海市轻工科技协会喷雾与气雾剂专业委员会、深圳彩虹精细化工有限公司、广东莱雅化工有限公司、上海西西艾尔气雾剂推进剂制造与罐装公司、广州立白集团公司、广东中山联昌喷雾阀公司、顺德第一人民医院、江阴比图特种纸片公司、厦门琥珀香精香料有限公司、上海信谊药厂有限公司、浙江仙琚药业有限公司、上海艾洛索化工技术研究所、上海（科协）喷雾与气雾剂研究中心及阿克苏诺贝尔（上海）有限公司等的大力支持、合作和帮助，在此一并予以感谢。

在此特别要感谢我国气雾剂行业的杰出代表深圳彩虹精细化工有限公司总裁陈永弟高级工程师，在百忙中给予关注和鼓励，并亲自为本书作序。

最后对化学工业出版社为本书做出的巨大支持和努力的编辑、校对，使《气雾剂理论与技术》得以如期出版，表示由衷的感谢。

蒋国民
2010年4月



During the process of the rapid development of Chinese aerosol industry in the end of 1980s, due to the lack of knowledge and technology, some people even took the opportunity to resell the overseas formula to many domestic enterprises at high prices of tens of thousands RMB. Some enterprises were charged for 5000-6000RMB only for the valve crimp size and personal injuries and deaths and fire accidents were caused by incorrect operation because of lack of knowledge in the features of flammable and explosive hydrocarbon propellant; some enterprises competed each other for technicians and aroused conflict; some didn't know how to choose the appropriate aerosol cans and aerosol content to match the aerosol valves, etc., all the above reminded me that a technical book was in urgent need to infuse fresh blood into our domestic industry and to meet the demand of rapid development to solve the immediate problems. Engaged in the development of aerosol products at that moment, I was much impressed by the situation in person.

For those outside the circle, or if judged superficially, aerosol products seem to be very simple in those eyes of the people and small enterprises who are still at the introductory stage in particular. That is, after purchasing the aerosol cans and valves, filling the material made according to the formula into the can as well as inserting the valve, then having the valve crimped, on the can, binding them tightly and gassing the propellant into the can, then an aerosol product is finally produced. The initially-used Freon was unburnable. Later on, not a few enterprises spontaneously replaced Freon by flammable and explosive mixture of propane and butane but without any changes in the production procedure and places, which reflected the lack of knowledge of the danger of flammable and explosive mixture of propane and butane.

The more simple it looks, the easier for people to be puzzled by and ignorant of it.

Therefore, a great number of people don't realize what they use is nothing but aerosol product. Besides, quite a few enterprises, knowing less about or even being ignorant of the knowledge and technology of aerosol product, are doing the business of producing aerosol product or aerosol can and valve, the components of aerosol product. And the developed countries are of no exception.

All the above have no great impact on the quality and function of aerosol products, though, still breed much potential danger. Under such situation, I, in the spirit of synthesizing the knowledge and experience, started to compile the *Aerosol Technology* as a guidebook for the industry.

Since the first *Aerosol Technology* published by Fudan University in October, 1995, to my relief, it more or less played a role in the newly emerged aerosol industry of our country. Doctor Zhang Yi who, for instance, took the position of the technical controller of Shanghai Huaxin Aerosol Company after graduated from Shanghai Jiangtong University, bought this book under his tutor's recommendation and made an appointment with me to have a face-to face discussion. What's more, Wang Xueming, the deputy technical director of Hebei Kangda Fine Chemical Co., told me that it was this book that guided him into the aerosol industry, All the mentioned served as a great encouragement for me.

Later on, I, along with some technology and business elite in the domestic circle, compiled a series of books one after another in the demand of the development of the industry, such as *Aerosol Propellant Handbook* written before the CFC substitution in 1997, *Aerosol Valve and Spray Pump Handbook* in 1998, *Aerosol Safety Technology* in 2000 which, under my proposal and by the sugges-

tion of State Environmental Protection Administration and State Administration of Work Safety, jointly compiled by Cheng Yongdi, the chairman of Rainbow Fine Chemical Co., Ltd., and Li Hong, the general manager of Shanghai CAL Aerosol Propellant Manufacturing and Canned Company, both of whom are experienced, and *Aerosol Safety Guide* compiled under the commission of UNEP and State Environmental Protection Administration in 2007.

During that period, proposed by some fellows both at home and abroad, we translated the four published books, namely *Aerosol Propellant Handbook*, *Aerosol Valve and Spray Pump Handbook* and *the handbook of insecticide formulations and its technologies for household and public health use* as well as *Aerosol Safety Technology* into English, which were largely appreciated by the American and European industry and rendered the western fellows think us differently, who were impressed by we Chinese capacity.

It has been 15 years since the first *Aerosol Technology* was published. Let alone the version has already been sold out, the domestic aerosol industry has undergone remarkable changes during the decades, thus a large number of problems require to be reconsidered. In terms of technological theory, though a series of specialized books have been published one after another, a comprehensive theoretical system of the 80-year-long world aerosol industry needs to be established to enable the whole industry to keep pace with the new demand and development.

Given this situation, I, considering the requirements and anticipation in all aspects, jointly cooperated with competent and well-educated experts and entrepreneurs from both at home and abroad to compile the book on the basis of the previous technical books and the research findings and practical results by our own experience and the new achievements in both the national and international industry in recent years.

It is known to all that the birth of aerosol product infuses new blood into daily-use chemical and pharmaceutical products. Aerosol products can be used in a wide range of area, which are complex and diverse in production process. Aerosol system is a multi-discipline integrated technology. Aerosol containers are made from metal materials, coatings, sealing and corrosion-inhibitors, which involve materials science, mechanics, processing technology, coating and printing, mechanical strength and test. Aerosol valves, the most important, complicated and changeable component of aerosol product, are involved from plastics, rubber and metal materials, which relate structural design, precision mold and molding process, injection rate control and the choice and measurement of atomization principle, selection and test of droplet size, crimp and leakage test, whose quality and fitness will exert a great impact on the expected spray patterns and performances.

Regarding the proportion and compatibility of various kinds of active ingredients, solvents and additives need to be considered, which involve formulation and preparation process design, as well as biology, ecology, toxicology, physics, chemistry, etc. Propellants, as the foundation and power source for aerosol products, on the one hand, are concerned about the protection of ozone—the umbrella of human beings, on the other hand, they also involve the safe operation of hazardous chemicals, transportation, storage and waste disposal in the production process, the concentration detect, alarm and ventilation of flammable and explosive gas mixture, fire and explosion prevention and emergency management, people's safety, compliance with various government regulations and laws. From the aspect of the integrity of aerosol products, they are not equal to the simple combination of the said containers, valves, propellants and concentration feed but involve the effect, applicability, safety and economic factors, considering the factors of mutual constraint, mutual interaction, mutual influence, the optimal combination design shall be filtered out by a series of experiments and readjusted to be comprehensively evaluated, during which process, the relative laws and regulations shall not be neglected and the requirements of consumers and market shall be met. Aerosol safety has become a worldwide concerned topic, which covers rich content. At the macro level, it greatly influences the human environment, such as the depletion of ozone, greenhouse effect and physi-