



Faculteit Wetenschappen
Departement Chemie

Optimization and environmental application of TW-EPMA for single particle analysis

*Optimalisering en milieutoepassing van TW-EPMA
voor de analyse van individuele deeltjes*

Proefschrift voorgelegd tot het behalen van de graad van
doctor in de Wetenschappen aan de Universiteit Antwerpen
te verdedigen door

Johan DE HOOG

Prof. Dr. R. Van Grieken

Antwerpen, 2005

voor mijn geduldige Marijke

Table of contents

Table of contents	I
Foreword and acknowledgement	II to III
Chapter 1 – Instrumentation	1-1 to 1-20
Chapter 2 – Quantification	2-1 to 2-66
Chapter 3 – Characterization	3-1 to 3-37
Chapter 4 – North sea aerosols	4-1 to 4-31
Chapter 5 – Characterization of PM2.5 in Flanders	5-1 to 5-45
Final remarks and conclusions	IV to V
Summary in Dutch	VI to VII
Contributions to scientific publications	VIII to IX
Contributions to scientific meetings	X to XII
Contributions to scientific reports	XIII

Foreword and acknowledgment

In the foreword for my master thesis five years ago, I tried to express that, although my work was obviously only a droplet in the big stream of scientific research, I felt part of the bigger whole. Although I was uncertain about where I would get the necessary funds to ‘survive’, and even though I didn’t know what the future would bring, I was about to extend my ‘academic life’ with a doctoral study.

Now, five years later, I know a lot more. I didn’t get the public funds that I initially wished for, but the university and my promotor Prof. Van Grieken in particular have always given me financial support, for which I am forever thankful. Of course there is no pleasure without pain, and in return for the money, I had to carry out projects for external clients. Other students that did get independent funds often wondered how it was possible to combine these projects with the more fundamental work that is needed for producing a doctoral thesis. However, looking back at the past five years, I think, for my case, I should be grateful for not getting the other funds, because I would have missed a lot of opportunities. I have trained my social skills, I had to deal with strict deadlines, and I learned to think thematically and customer-oriented. The acquired competences and experiences turned out to be helpful while finding a job after my Ph.D, and maybe I would not have my current position if I could not rely on the experience that I built up over the past few years. Therefore, I wish to thank the people at MiTAC, VITO, VMM, AMINAL, (R)UG, VUB, ULB and ELICO, whom I had the honour to work with and for.

The projects were also extremely helpful for my doctoral research. Unlike many of my colleagues, I did not have to beg continuously for samples, research topics, etc., because I had plenty. The application of the optimized technique to many different environmental samples gave rise to many ideas and challenges in the fundamental part of my thesis, so I think I could speak of a perfect symbiosis. Of course, I am obliged to show my respect to my scientific fathers and friends, Chul-Un Ro, János Osán and Imre Szalóki, who truly made this thesis possible. Without their support and inspiration, the fundamental part of this thesis would not have been what it is today. They each have a different way of dealing with problems, and the valuable coincidence (or maybe ‘providence’) of meeting these beautiful minds together provided me with an exciting amount of multicultural mental nourishment.

The fact that I also had the chance to travel around the world and meet many other cultures, was of course a nice bonus. Therefore, I owe Prof. Van Grieken more so. Although we did not always share the same opinions, I hope he knows I have always respected him, and not just for the material advantages of being a student in his research group.

I am also eternally grateful for the support that I got from the few real friends that I made at university, especially in our group. We received some hard lessons in life, but somehow we managed to fight bad times and disappointments by small victories. I will never forget you and I wish all the best to you and your families. And never forget that life is like a box of chocolates.

One other evolution since the start of my Ph.D. is that I had to exchange some of my naivety and idealism for cynicism. I found that the aforementioned stream to which I contributed as a droplet, was very big and had many tributaries that took away its strength. I experienced that the scientific world is not as charitable as I thought it was, and I found that the world around us is not black or white, but grey. Environmental research is looked at with Argus' eyes, since a lot of interests are at stake, and big money is involved (both in the camp of the environmentalists and in that of the other stakeholders). Although science in my opinion is still the only solution to find just and righteous answers to the many existential problems that manhood encounters, its progress is slower than I expected, because it is the victim of its own uncertainty. The greyness in life is reflected in science as well: it is very hard for any scientist to draw black or white conclusions that can be guaranteed for 100% (or at least 99%). The danger is that outsiders abuse scientific conclusions to convince the world that their opinion or conviction is the only right one. Hidden agendas, lobbying and false media have become more manifest than ever, and they are applied at both sides of the spectrum. For example, the commotion around the book of Björn Lømborg ('The skeptical environmentalist'), in which he tries to show that environmental pessimism is not always appropriate, has led me to the conclusion that our society desires more from science than it can currently offer. Since my thesis work, I have experienced many times that political decisions were based on incomplete or raw data, without taking the proper time for making clear interpretations and drawing the right conclusions. Offensive environmental lobbyists (pro and contra) enforce decisions that impose high pressure on society. Every player in the game gives his interpretation of the facts, while the referee (science) has become the ball that is tossed around to score. Therefore, I should rephrase the statement in my master thesis: my scientific contributions remain droplets, but the scientific 'stream' has turned into a stone. The image of small droplets falling onto an almost immovable 'stone' might appear a rather desperate perception of the scientific world to the reader. However, I learned from an old and wise proverb that 'every drop is able to move a stone', so I still hope that I have contributed in some way to make this world a better place.

Last, but not least, I am obliged to mention the other changes in my life that were more personal. During my studies I met my lovely Marijke, my prop and stay, who would also become my wife some time later. Besides the vows that we took, I also promised her that, since she is a nurse, I would become her doctor some day. In 2003, however, I left university to find new challenges at BASF in Antwerp. A small miracle, Joppe, soon made our life even more glorious than we could ever have wished for.

Our families, friends and colleagues know how hard it was to combine these glad but turbulent tidings with writing a Ph.D. I should thank all of them for their patient support, especially my parents and my sister who have been there for me from the beginning. Nevertheless, if patience is a virtue, I am sure that Marijke is a goddess, and although I will never be able to make up for the time that we have lost, I seek comfort in the fact that we both believe it was worth the effort.

Antwerp, 2005
Johan