Magnetic Resonance Detection of Explosives and Illicit Materials

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Magnetic Resonance Detection of Explosives and Illicit Materials

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Preface

In their preface to a previous volume in this series (*Explosive Detection using Magnetic and Nuclear Resonance Techniques*, 2009), editors Profs. Fraissard and Lapina laid out the potential advantages and recognised challenges of the application of magnetic resonance techniques including Nuclear Magnetic Resonance (NMR) and Nuclear Quadrupole Resonance (NQR) spectroscopies to the detection of explosives [1, 2] in a world where individuals and groups were employing an ever-widening range of homemade explosive materials for use in so-called improvised explosive devices (IEDs). The key advantages of magnetic resonance methods are that they employ radiofrequency waves that are chemically-specific, non-invasive and non-destructive and that are able to pass through many materials including woods, plastics, fabrics and soils. In the case of NQR, the key challenge is the low sensitivity – low “signal-to-noise” ratio – making the highly-specific signals hard to pick out amongst the background radiofrequency noise, particularly in unshielded environments. In the case of NMR, the challenges are the need to incorporate a magnet in the detection system, with inherent issues with weight and the effect of magnetic fields on electronic equipment; and the need to differentiate threat from benign liquids.

In the years since the publication of that volume, the number of attacks and diversity of materials and methods employed have, alas, only increased. There has been continuing violence in places such as Iraq, Afghanistan and the Caucasus; and prominent isolated attacks and attempted attacks elsewhere in the world including the “underwear bomber” (explosive: PETN; December 2009), the Times Square car bomb (explosives: black powder and urea; May 2010), the “printer bombs” (explosive: PETN; October 2010), the Domodedovo Airport suicide attack (explosive: TNT; January 2011), right up to the Boston bombings of this year employing pressure cookers (explosive: black powder; April 2013). At the same time, other developments, such as the ban on air passengers carrying liquids containers larger than 100 ml in their carry-on luggage being due to be lifted in the next year, have focussed the attention of equipment makers and legislators both on the need to deploy non-invasive technologies for this, specific application.

So how have magnetic resonance methods progressed towards meeting the challenges laid out by Profs. Fraissard and Lapina in their preface to the 2009 volume in the face of the still-diversifying threat and other developments? This current volume presents a snapshot of progress in the application of NQR to the detection of solid explosives and the application of NMR to the detection of liquids explosives; with papers covering other techniques, for example Terahertz spectroscopy (THz), that illustrate parallel efforts in similar fields.

The NQR papers deal directly with the issue of signal-to-noise and can roughly be divided into two types: those concerned with increasing the strength of the signals generated (Rudakov and Mozzhukhin et al.) and those concerned with increasing the specificity of the technique through a better understanding of the factors that affect the quadrupolar parameters of specific formulations of explosives (Rowe et al.; Malone and Sauer; Sinyavsky et al.; Jover et al.). There is in addition an important paper on the application of signal processing techniques that make use of these specific quadrupolar parameters to aid in situations where signal-to-noise is poor (Butt et al.). This focus serves to illustrate the recognition in the NQR community of the paramount importance of improving signal-to-noise and discrimination, with the latter of particular importance as the range of threat materials grows – the spectrum of NQR responses from explosives is a much more crowded place in 2013 than it was just 10 years ago.

The NMR papers are united in their focus on the issue of differentiating threat liquids from benign liquids, although the approaches taken are diverse, ranging from a method that uses a multi-element NMR (^1H , ^{14}N) approach (Prado) to those that focus on characterising different time constants of the ^1H signal alone (Austin et al.; Konov et al.) and consider different configurations for capturing these different ^1H time constants (Gradišek et al.). These papers – particularly the Prado and Austin et al. papers – incidentally also illustrate a trend for the development of more compact systems that has overtaken NMR for the detection of explosives in recent years; a recognition that, any system that hopes to be deployed in an environment as crowded as an airport security lane needs to have as small a footprint as possible.

This volume is based on NATO Advanced Research Workshop “Magnetic resonance detection of explosives and illicit materials” MRDE-2012 and Editors acknowledge the support of NATO by ARW grant 984375. Additionally, many of the authors would like to acknowledge the NATO support by Science for Peace grants 978007 “A Quadrupole Resonance Instrument for the Clearance of Abandoned Minefields”, and 982836 “Highly Sensitive NQR/NMR Technique for Explosive Detection”.

While working on the current volume, the editors received the sad news that Prof. John A S Smith had passed away. John Smith was a leading light in the NQR community for nearly 50 years, forming his first NQR research group at the University of Warwick, UK, in 1965. There, he co-invented (with his then research student, David Tong) a Nuclear Quadrupole Resonance Spectrometer, which was manufactured, and exported, by Decca Radar Instruments. In 1972, shortly after moving to Queen Elizabeth College (QEC), London, John organised the first International symposium on NQR. In 1985, following a merger, QEC became

part of King's College London, and it was there that John spent the whole of the rest of his career. In the course of that career, he was the co-author of more than 200 papers and reviews in the scientific and technical literature, and joint holder of 16 patents. He was also, for many years, the editor of the *Advances in Quadrupole Resonance* series published by Wiley & Sons. He maintained a keen interest in mine and IED detection technology and airport security scanning technology, as can be evidenced from his publication in this current volume, the last that he completed before his death. John was a true gentleman as many people who met him can attest. All his life, he was dedicated to Chemical Physics and at leisure, to his wife and daughter, sharing his love of opera and art culture with them.

The 2013 Magnetic Resonance for the Detection of Explosives Workshop (MRDE2013), held at King's College London, 8–12 July 2013, was dedicated to John's memory.

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