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Abstract To facilitate just and sound decisions legal measurements must be reliable. The aim of this paper is to explore how this is currently achieved and how it might be better done. It considers the different types of legal proceedings, the role of chemical measurement, level of proof, the different types of chemical measurement, measurement units, the role of government, the chemical measurement industry and its control, legal metrology and the development of a measurement system based on metrological principles. It is argued that recent developments provide the basis for a robust support system, that but more needs to be done. It is also argued that the conventional approach to legal metrology has little place in chemical measurement, but that some controls are needed in some areas. In particular, a harmonised approach to international measurement standards is advocated.

Keywords Metrology in chemistry · Law · Regulation · Quality · Standards · Traceability

Introduction

Chemical measurements can constitute a form of legal evidence, which is often provided in the form of a written expert witness statement. An expert witness is required to be impartial and to provide guidance on issues where a court cannot be expected to have expert knowledge. Experts are limited in their use of “hearsay evidence” and must have carried out or closely supervised the work reported. However, an expert witness might also provide evidence of other published work and “opinion”. The expert is subject to challenge and cross-examination during the trial, or during pre-trial examinations. It is not the job of the expert to make decisions in legal proceedings – that is the job of the judge and jury. In addition to serving the court, the expert’s evidence may lead to the decision not to prosecute or to engage in legal dispute.

Chemical measurement evidence might contribute to a larger picture or be the key evidence. An example of the former is establishing that the chemical composition of an ink closely matches that found in the possession of an accused. An example of the latter is where controlled toxic substances exceed levels set by food safety regulations. Some chemical measurements are made in the full knowledge that they will be used as evidence in legal proceedings. Other measurements become involved in legal matters and in principle any measurement can become a legal measurement. Clearly, the importance of the chemical measurement will vary from case to case. Legal measurements are not necessarily more important than other types of measurement, but they are often subject to greater scrutiny and special procedures often surround their production and use.

Legal measurements must of course be reliable and facilitate just and sound decisions. The aim of this paper is to explore how this is currently achieved and how it might be done better.

Types of legal proceeding

Legal proceedings take many forms, including “criminal” and “civil” prosecutions, “enquiries” and “investigations” of rule breaking, such as the International
Olympics Committee’s rules banning athletes from taking performance-enhancing drugs. The exact procedures vary from one type of proceedings to another and from country to country, but there are many common basic requirements. Most countries have “legal metrology” regulations, which control certain measuring devices, particularly those associated with weighing machines, volume meters (e.g. fuel meters), Taxi meters, etc. These controls particularly apply where short measure might be readily used for fraud. Some countries, including Australia and Germany, have a national measurement act, which specifies certain requirements concerning traceability to national standards, the types of units that can be used, etc. In most cases, however, it is for the court to decide what evidence to believe and how much weight to give to it.

The role of chemical measurement

One of the uses of chemical measurements is to help detect crime and identify law-breakers. In this capacity, the analyst or forensic scientist works in close association with law enforcement agencies. Although the measurements must be designed and performed impartially, the situation is different from that where the measurements are provided to help a court arrive at a just decision, particularly where the adversarial system is employed. In the latter circumstances the police represent one side in a case, the prosecution, whereas the expert witness is required to be impartial. Too close an association with the prosecution might lead to bias. Because of the cost of expert witnesses, and the potentially unfair advantage afforded to the prosecution (or one side in a civil case) in terms of access to experts, there is a growing tendency for expert evidence to be made available to both sides in a dispute. This includes evidence not actually used in court. Pre-trial review, where expert evidence can be agreed, or areas of dispute identified, before the trial is becoming increasingly common. Another approach is for the court to appoint a referee to advise in the event of a dispute over chemical measurement. In the UK this is enshrined in acts of Parliament, where the Government Chemist is required to perform this function. The situation is similar in the USA, where the National Institute of Standards and Technology can be called upon to act as referee.

Types of chemical measurement

Chemical measurement evidence is of two basic types, namely, “identity” and “amount”. In addition, there is associated “opinion” evidence which involves evaluating the significance of factual evidence, such as the closeness of match between two specimens of ink and its significance in associating an accused with a crime.

Identity

Examples of identity evidence include:

1. identity of an unknown, e.g. the identity of a white powder found in the bearings of a crashed aircraft engine;
2. confirmation of identity, e.g. was the white powder found on the premises of a suspected drugs dealer cocaine? and
3. identity of trace amounts, e.g. was an explosive material present in swabs taken from the hands of a suspected bomber.

The identity of interest might be of a discrete chemical entity or a complex mixture such as a paint. The evidence can be one or more of three types:

1. information about source and manufacture of a material, e.g. where samples of metal can be traced to a