

A Simplified Guide to Forensic Drug Chemistry

Introduction

From the cocaine dealer on the corner to the clandestine meth lab in the abandoned trailer to hundreds of pounds of marijuana seized by the Coast Guard, illegal drugs permeate modern society. Even prescription medication can be an illegal drug if sold or given to someone for whom it was not prescribed. Over the past decade, new and more dangerous synthetic drugs have come to market. Their producers attempt to circumvent the law by continuously altering the chemical composition of the substances to avoid prosecution.

The illegal drug trade creates a global black market economy that puts the public at risk, not just from the substances being distributed, but also from the subsequent crimes committed by users, traffickers and manufacturers. These crimes typically include burglary, assault and fraud, but can also involve more serious crimes such as homicide, abduction and human trafficking.



Marijuana leaf. Courtesy of NFSTC.

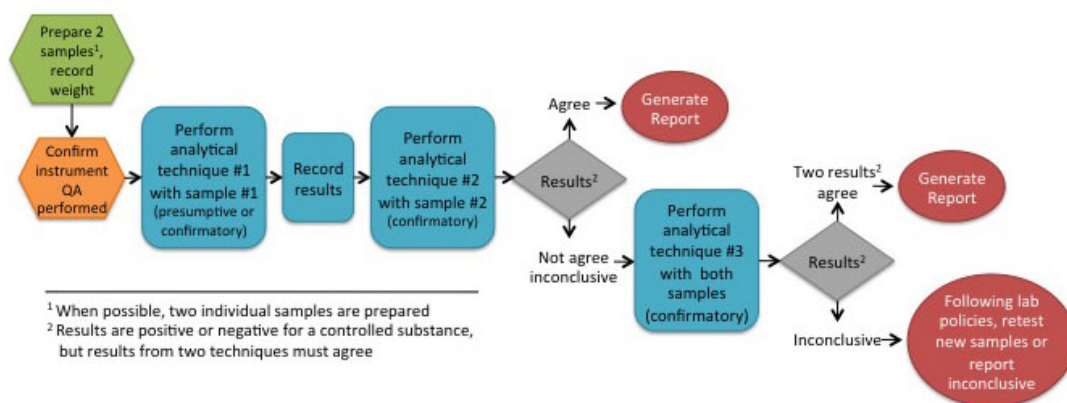
Forensic drug chemistry uses a series of processes performed in the field or laboratory to detect the presence or absence of controlled substances. Chemical analysis performed in the laboratory on submitted evidence detects and identifies illegal drugs, and helps law enforcement prosecute offenders. This practice uses a variety of chemical analysis methods to conduct both presumptive and confirmatory tests on seized material suspected to be or contain illegal substances. Results from this analysis often

serve as the basis for criminal proceedings and help to determine sentencing for convicted offenders.

Principles of Forensic Drug Chemistry

Forensic drug chemistry is simply chemistry as it is applied to the identification of illegal substances within the criminal justice system. Like all other chemistry disciplines, it examines the way the atoms and molecules in matter interact and bond with each other. All matter has a chemical signature, or set of characteristics that are unique to only that substance. Chemists use these characteristics to identify substances using scientific methods that can be replicated by other chemists and thus are presentable as fact in court. Forensic chemistry covers illegal drugs, explosives and poisons.

Overview of Chemical Analysis Process for Controlled Substances



What makes a substance illegal?

An illegal drug is defined as a substance that causes addiction, habituation, or a marked change in consciousness, has limited or no medical use and is listed on one of the five schedules within the **U.S.C. Controlled Substances Act**. These schedules include drugs such as cocaine, heroin, methamphetamines, certain prescription drugs, and marijuana, among many others.

In forensic drug chemistry, analysts use scientific findings to help investigators pursue legal action against individual(s) suspected of a drug-related crime. The goal of forensic drug chemistry is to determine whether the material submitted contains an illegal substance. Based on the results of the analysis, law enforcement can pursue criminal charges and the court can determine appropriate sentencing.

Forensic drug chemists analyze samples of unknown materials including powders, liquids and stains to determine the chemical identity or characteristics of the compounds that make up the sample. Samples submitted as evidence in a drug-related case can contain one compound or a mixture of many compounds. For example, cocaine powder is often cut with other substances such as caffeine or lidocaine. The forensic chemist who receives the sample suspected to be cocaine will need to separate out all the individual compounds and test to see if one of those is cocaine. They do this by looking at the chemical characteristics of each compound and comparing those characteristics to reference material analyzed using the same instrument.

Presumptive and Confirmatory Testing for Drugs

There are two main types of tests used to determine whether an illegal drug is present in a substance: presumptive tests and confirmatory tests. Presumptive tests are less precise and indicate that an illegal substance may be present. Confirmatory tests provide a positive identification of the substance in question.

Presumptive testing may be conducted in the field by law enforcement officers or in the laboratory once the seized material is accepted. Confirmatory tests involve a battery of instrumental tests using techniques such as Gas Chromatograph-Mass Spectrometry (GC-MS) or infrared spectroscopy that separate individual compounds in the substance and positively identify the chemical signature of the illegal substance(s) within the material.

The specific tests performed can vary from lab to lab depending on the procedures set in place by the agency. Presumptive tests may also be conducted at the point of seizure by law enforcement; however, confirmatory tests are typically performed in the laboratory.

Presumptive testing – are usually colorimetric, meaning the test will indicate that the suspected substance is present or not present by changing color. If the substance is present, the test kit will turn one color, if not, it turns a different color. Presumptive testing by law enforcement is typically followed up with laboratory tests that confirm with certainty the presence of the suspected substance. Presumptive testing is also performed in the laboratory as part of the analysis process.



Colorimetric test to detect the presence of methamphetamine or MDMA (Ecstasy). Courtesy of NFSTC.

Confirmatory testing – uses instrumental analysis to positively identify the contents of submitted material. This typically requires a multi-step process to separate the individual compounds, determine the chemical characteristics of the compounds, and compare them against reference materials to make a positive identification. This is called qualitative analysis, and determines what substances are present and if one or more of those substances is illegal.

The analyst may have an idea, based on information from presumptive tests or the submitting agency, of what type of drug is contained in the sample. This information, as well as the laboratory policies in place, will determine what tests the analyst will use. A typical battery of tests will include separation techniques to separate the various compounds and spectroscopy instruments to identify the chemical characteristics.

Confirmatory tests, depending on the lab requirements, may also include quantitative analysis of the sample to determine the amount, or purity, of the illegal substance. The purity of the illegal substance is used for sentencing purposes at the federal level. For example, a sample that contains 80 percent pure dextro-methamphetamine HCl will carry a harsher sentence than a sample containing a lesser purity of the drug. High purity often indicates manufacturing or trafficking drugs in bulk quantities for further distribution. A determination of purity is most often required in Federal cases.

Drug Scheduling and Classification

To determine if a substance is illegal, the analyst compares the chemical signature of the compound against those listed on the controlled substance schedules. These schedules, as defined by the Controlled Substances Act, establish penalties for the possession, use or distribution of illegal drugs. Substances are scheduled depending on their potency, potential for abuse, likelihood of physical dependency, and legitimate medical use as outlined below.

- Schedule I – no medical usage, high potential for abuse. Examples include Heroin, LSD, peyote, MDMA
- Schedule II – severely restricted medical usage, high potential for abuse, but slightly less than Schedule I drugs. Examples include cocaine, methamphetamine, methadone, oxycodone
- Schedule III – currently accepted medical usage, moderate potential for abuse, and moderate to low risk of dependence. Examples include barbiturates, steroids, ketamine
- Schedule IV – widely used for medical purposes, low potential for abuse and low risk of dependency. Examples include Xanax®, Valium®, tranquilizers
- Schedule V – widely used for medical purposes, very low potential for abuse, contain limited quantities of narcotics. Examples include Rokitussin® AC, Tylenol® with Codeine

Illegal drugs are also classified by category based on the way in which the drug affects the human body and brain. These categories help law enforcement to understand what drug or drugs a person may have taken based on their behavior, appearance and circumstances. For example, a person who has taken a stimulant drug such as methamphetamines will react or respond to police differently than a person who has consumed a narcotic or marijuana. Understanding how different classes of drugs can affect individuals helps law enforcement officers react to, control and question suspects in drug-related cases.

Class	Some Common Effects	Examples
Marijuana	Euphoria or “high”, altered sensory perception, sleepiness, disrupted coordination/balance	Marijuana, hashish
Narcotics	General sense of well-being, drowsiness, inability to concentrate	Opium, heroin, morphine, methadone, oxycodone
Stimulants	Euphoria or “high”, exhilaration, wakefulness, agitation, hostility, hallucinations	Amphetamines, methamphetamines, cocaine

Depressants	Sleepiness, amnesia, impaired judgment, confusion, slurred speech, loss of motor coordination	Alcohol, barbiturates, benzodiazepines, GHB, Rohypnol
Hallucinogens	Altered perception and mood, mild to severe hallucinations	LSD, MDMA, PCP, ketamine, mescaline/peyote, mushrooms (psilocybin)
Synthetic drugs	Agitation, irritability, impaired perception of reality, reduced motor control, inability to think clearly	Bath salts (cathinones), DXM, salvia
Steroids	Mood swings, hostility, impaired judgment, aggression	Human growth steroids, testosterone
Inhalants	Loss of inhibition, intoxication, slurred speech, decreased coordination, euphoria, disorientation	Ether, nitrous oxide, butane, cyclohexyl nitrite, amyl nitrite

Synthetic Drugs

In recent years, use and abuse of synthetic drugs, including “bath salts” (cathinones) and “spice” (synthetic cannabinoids/marijuana), has risen dramatically in the U.S. Between 2010 and 2011, poisoning incidents relating to synthetic marijuana rose by 50% according to the American Association of Poison Control Centers. The number of reported poisonings by “bath salts” in 2011 was 20 times higher than in 2010. The danger posed by these drugs comes mainly from their marketing as legal substances labeled “not for human consumption” to circumvent existing legislation and growing evidence of their highly addictive nature. According to the National Institutes of Health, not much is known about their long-term effects on the human body; however, studies indicate they may be more addictive than many scheduled substances. Synthetic marijuana has become the second most abused drug among high school students, exceeded only by marijuana itself.



Synthetic marijuana commonly known as "spice".

Prescription Drugs

According to the National Institute of Health, more people die from overdoses of prescription opioids than from all other drugs combined, including heroin and cocaine. Abuse is most prevalent among high school and college-aged students. Abusers often think that these substances are safer than street drugs because they are manufactured for medical use. However, when taken in ways or by individuals for which they are not prescribed, they can be as dangerous and addictive as any other controlled substance. In 2007, the CDC reported approximately 12,000 unintentional poisoning deaths involving non-medical use of prescription drugs. Additionally, among individuals who reported illegal drug use on a national survey, nearly one-third indicated that they started with non-medical use of prescription drugs.

Applications

Why and when is forensic drug chemistry used?

A sophisticated law enforcement operation carried out in 1989 against Mexican cocaine trafficker Rafael Munoz Talavera captured 20 tons of cocaine in a warehouse in Southern California worth nearly \$7 billion. The operation started with a tip about a suspicious truck parked in front of a warehouse and ended with six warehouse workers sentenced to prison. To get those convictions, prosecutors needed to prove the substance in the warehouse was cocaine and that it was intended for distribution.



Bricks of bulk cocaine, a common packaging method used to transport drugs for trafficking. Courtesy of NFSTC.

Forensic drug chemistry is used in cases involving the possession, trafficking or manufacturing of a suspected illegal substance. An investigator with a reasonable suspicion that an individual or individuals are in possession of an illegal substance may perform presumptive testing at the scene. Depending on the results of the presumptive test and agency procedures, samples will typically then go to the forensic laboratory for confirmatory testing. Analysts answer basic questions about suspect materials including:

- What substances are present within the sample?
- Is any component within the sample an illegal substance?
- How much of the illegal substance is present within the sample?

Illegal substances can be involved in many types of crime situations including rape scenes, overdoses, burglaries, murder scenes, clandestine drug manufacturing such as methamphetamine labs, domestic and other abuse scenes, traffic accidents, and many others. Law enforcement or other agencies may confiscate drugs directly from users or dealers, seize large amounts in raids of suspected manufacturing locations or grow houses, capture substances during transportation to or from the U.S., or discover stashes due to other crimes. In crimes where illegal drugs are involved, punishments are more severe than non-drug related crimes. Confirmatory testing in the laboratory is required for prosecution and appropriate sentencing of suspects.

One of the primary functions of forensic drug chemists, in addition to testing materials in the laboratory, is to present testimony in court. Forensic chemists are routinely required to serve as expert witnesses during criminal procedures for cases in which they have performed confirmatory testing. This testimony will often include discussions of laboratory procedures,

quality control within the laboratory, maintenance and calibration of the instruments used in testing as well as the details of the analysis report.

How It's Done

Evidence That May be Collected

Evidence collected during an investigation involving illegal drugs can include the substance itself, containers used to transport the substance, utensils used to manufacture or use the substance, or in the case of manufacturing, the component chemicals used to create an illegal substance. Drugs can take the form of pills, powders, liquids, plant material such as leaves and mushrooms, crystalline materials (crystal methamphetamine), and cases such as MDMA or ecstasy, can be imbedded in paper or foods like candy.



Crystal methamphetamine. Courtesy of NFSTC.

At crime scenes where illegal substances are suspected to have played a role, the substances in question could be residue on other items or liquids that have soaked into fabrics. In these situations, the evidence collected could be anything within the crime scene including biological samples, most commonly blood or urine, from victims and suspects.

In cases of drug smuggling, illegal drugs can be transported in small amounts through luggage or on an individual, hidden in innocuous places such as cosmetic bags or medicine bottles. Often drugs are smuggled inside the body using plastic bags or other small soft containers that fit into cavities or can be swallowed and regurgitated. However, drugs smuggled in large volumes may come through cargo shipments of other goods such as canned or boxed food items, prepackaged consumer goods, garments or fabrics, and hollow items such as ceramics or tubing. There are an unlimited number of

channels for smuggling drugs into the country and evidence could include anything from personal handbags to entire shipping containers and their contents as part of these cases.

For example, in December 2012, Customs officials at the Miami International Airport found 231 pounds of cocaine worth approximately \$2.7 million dollars in three suitcases arrived from Ecuador. In a larger smuggling case from 2008, Australian authorities seized 4.4 tons of MDMA worth more than \$300 million. The pills were being smuggled inside tomato cans imported from Italy.



Dogs trained to detect the presence of illegal drugs are often used at locations that could be used to smuggle drugs into or out of the country such as airports or train stations.

How the Evidence Is Collected

Drug evidence is collected using the same evidence collection methods used for other types of crimes. Evidence is collected, photographed, packaged, documented and sent for analysis using the guidelines and processes in place at the responding agency. Packaging of the drug is based on the type of material present. For example, plant material should not be packaged in plastic due to the moisture content and tendency to grow mold. If investigators collect a syringe or other sharp object, those are packaged in hard-sided packaging such as cardboard cartons or glass vials and labeled as a potential biohazard. Any biological samples collected would be packaged according to proper evidence handling procedures.

In the case of drug manufacturing or clandestine laboratories, investigators may be faced with hazardous conditions. Many of the chemicals used to manufacture illegal drugs are toxic or volatile and must be packaged in small amounts using specialized containers to protect the safety of laboratory staff

package handlers. Most agencies have strict guidelines for the processing of clandestine laboratories and packaging of collected materials.

Who Conducts the Analysis

Law enforcement officers or other investigators in the field may employ presumptive colorimetric test kits or handheld instruments to analyze samples. This form of analysis is presumptive only and helps the investigator determine if a substance could be illegal and take appropriate action. Agencies that may conduct presumptive testing include police, border patrol, customs, corrections, National Park Service rangers, homeland security personnel and federal agents. Whether or not a presumptive test is conducted, the collected material will be submitted to a forensic laboratory for confirmative testing.

According to the 2009 Census of Publicly Funded Crime Laboratories, an estimated 1,356,000 requests for analysis of potential controlled substances were made to crime labs in the U.S. That equates to 33 percent of all requests made to these labs and is second only to DNA testing requests.

Once a sample reaches the laboratory, it will be subjected to a battery of tests by a trained forensic chemist who specializes in drug chemistry. Forensic chemists must meet specific educational and training requirements in order to handle evidence, and every agency or jurisdiction has different criteria for meeting these requirements. The Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG) publishes recommendations for minimum levels of education, training and continuing education for analysts.

How and Where the Analysis is Performed

Collected evidence is sent to a forensic laboratory where a trained forensic drug chemist will perform several series, or batteries of tests and complete an analysis report that can be used in court proceedings. Each laboratory has specific procedures for analyzing evidence including the number of presumptive and confirmatory tests performed. In general the analysis includes:

1. **Weight test** – this determines the net weight of the material. Evidence submitted can range from residue on a surface to stains on fabric to pounds or tons of seized material. Analysts use analytical balances to weigh the material and record the results for the analysis report. The weight test will also determine if the quantity of material is sufficient for further testing.
2. **Presumptive testing or screening** – this determines the general characteristics of the sample material and allows analysts to narrow

down the field of confirmatory tests that will be used. Presumptive laboratory tests may include:

- **Microscopic analysis** looks at the structure of the material to make a preliminary estimate as to what it may be. This test is most suitable to plant material.
 - **Microcrystalline test** involves dissolving a small amount of the sample in a solution and letting the material form crystals. Substances will crystallize in a specific manner allowing analysts to identify components of a sample by viewing the crystals under polarized light.
 - **Ultraviolet spectroscopy** works by exposing the material to UV light and measuring the way the material absorbs the light. Different chemicals absorb light differently and can give clues to analysts about what might be present in the material.
 - **Gas chromatography** may provide presumptive identification of materials, but is commonly used to separate components prior to confirmatory testing.
3. **Confirmatory testing** – this includes separation and identification of the individual components of the material. Confirmatory testing is usually a two-step process by which the analyst first separates the compounds using a suitable method such as gas chromatography (GC), capillary electrophoresis, or wet chemistry. Once the components are separated, instruments such as a mass spectrometer (MS) or infrared spectrometer (IR) are used to identify each component by comparing its chemical signature against reference materials.

These processes may be combined depending on laboratory policies. The most common is gas chromatography/mass spectroscopy (GC/MS); however gas chromatography can also be combined with infrared spectroscopy (GC/IR) among others. The most common techniques used to separate the compounds in a sample include:

- **Gas chromatography** – an instrument that separates substances into individual components by dissolving the material in a liquid solvent, injecting the liquid into a superheated oven, vaporizing the liquid and pushing it through a very small, very long, glass capillary tube using a carrier gas such as helium or hydrogen. The mixture separates into individual chemical components inside the tube. As each component travels through the tube at a slightly different speed, the analyst can measure the time it takes each component to emerge and compare that to reference materials.

- **Liquid chromatography** – is similar to gas chromatography, however the evaporation phase using the superheated oven is removed. The material is dissolved into a liquid and injected into a wider, shorter stainless steel capillary tube at a high pressure. The components will then separate inside the tube and emerge at different times. This method is used when the material may be sensitive to the high temperatures required in gas chromatography.
- **Capillary electrophoresis** – uses an electrical field to separate the components inside a capillary tube. Molecules move toward the positive or negative charges placed at either end of the tube and analysis can measure the speed and direction at which they move to compare against reference materials.
- **Wet chemistry** – involves the use of liquid solvents to separate compounds.

Instruments most often used to identify compounds include:

- **Mass spectrometry** – once the components of a material are separated, mass spectrometry uses a beam of electrons that causes them to break apart. Chemicals always break apart in the same way due to their chemical structure and this can be mapped into a spectrum and compared against a database of known spectra.
- **Infrared spectroscopy** – uses infrared (IR) light to decipher the chemical signature of materials, specifically the bonds between atoms. Different components in a sample will absorb IR radiation differently and analysts can use this information to compare against reference materials.

Frequently Asked Questions

What kind of results can be expected from forensic drug chemistry?

The results of chemical analysis performed on submitted samples will yield a report that contains details about the materials submitted, the analysis that was performed and the results of that analysis. This report generally contains the total weight of the sample, the individual components within the sample, and the amount of each component found. Often, the report will identify the schedule of any illegal substances found in the sample.

What are the limitations of the analysis?

The main limiting factor in forensic drug chemistry is the size and condition of the sample. If the sample collected does not contain enough material to be

accurately measured and tested, then the analysis would be limited and the results may be inconclusive. For example, investigators may collect a piece of fabric with a suspicious stain and send it for analysis. There is no way for the analyst to accurately measure the weight of the material soaked into the fabric, thus the total amount of the substance will be unknown. However, the analyst can determine if there is an illegal substance present and the concentration of the substance.

Improperly packaged materials present a similar problem for analysts. For example, plant material such as marijuana or mushrooms that has been packaged improperly may become degraded before analysis can be performed. In cases of improperly packaged samples, destruction of the material can significantly reduce the amount of the sample available for analysis.

How is quality control and assurance performed?

To ensure the most accurate analysis of evidence, the management of forensic laboratories puts in place policies and procedures that govern facilities and equipment, methods and procedures, and analyst qualifications and training. Depending on the state in which it operates, a crime laboratory may be required to achieve accreditation to verify that it meets quality standards. There are two internationally recognized accrediting programs in the U.S. focused on forensic laboratories: The American Society of Crime Laboratory Directors Laboratory Accreditation Board and ANSI-ASQ National Accreditation Board / FQS.

In addition to these, individual laboratories have specific policies and procedures that govern the way analysis is performed in the lab. The Scientific Working Group for the Analysis of Seized Drugs (**SWGDRUG**) publishes recommendations for the analysis and quality control of forensic laboratories performing chemical analysis. This includes proper evidence handling and control, calibration of the instruments used, documentation methods, materials handling and storage, analytical and verification procedures, report writing and case review. These **recommendations are available online**.

What information does the report contain and how are the results interpreted?

Once the sample material is analyzed, the information is included into a report that provides the submitting agency with details about the sample including the components contained and the quantities of each component. In some cases, particularly federal cases, the report will also contain the purity of the illegal substances found in the sample.

Guidelines set forth by SWGDRUG recommend a report contain the following information:

- Laboratory and submitting agency information
- Description of all items and samples submitted
Ex: One brick-shaped package of compressed white powder
Several round, red tablets marked ABC
One plastic page containing compressed plant material
- Results of the analysis
Ex: Powder was analyzed and found to contain cocaine HCl.
Net Weight: 1024.6 ± 1.2 grams (95% confidence level).
- Tests/Techniques: weight determination, Gas Chromatography/Mass Spectrometry (GC/MS), Fourier Transform Infrared Spectroscopy (FTIR)
- Analyst signature
- Dates of submittal and analysis
- Any remarks from the analyst

Are there any misconceptions or anything else about forensic drug chemistry that would be important to the non-scientist?

All controlled substances are not illegal, and all drugs are not controlled substances. There is a general misconception that controlled substances and illegal drugs are the same thing. This is not the case – many drugs are controlled substances with perfectly legitimate uses. For example, not all narcotics are illegal. Many are legal with a prescription from a doctor. However, narcotics possessed or used without a valid prescription are considered illegal substances. Drugs that have been scheduled by the government usually pose a danger with improper use. Some drugs are scheduled because they have no legitimate use and pose a serious threat when used at all, such as LSD or MDMA.

There are also many illegal drugs that are not controlled substances. This stems from the rapidly changing synthetic drug trade, which includes substances such as “bath salts.” Manufacturers change the chemical formulas for these drugs often and market them as “not for human consumption” to circumvent existing drug laws. However, these substances are highly dangerous and law makers are working to draft legislation to control these substances.

TV crime drama vs. courtroom testimony

The detective on television who smells or tastes an unknown substance and declares, “it’s heroin” is doing something that would be very dangerous in real life. Drugs cannot be identified by smell, taste, appearance or other visual characteristics. Only properly performed chemical analysis by

qualified analysts can determine the composition of a substance. The TV detective who tastes the strange white powder is not only contaminating evidence, he may also end up inadvertently poisoning himself in the process.

Television crime dramas often portray chemical analysis as a quick process that can often be performed right at the scene. This is absolutely not the case. The colorimetric and other field devices used by law enforcement do not provide full chemical analysis. Handheld devices that use lasers to detect chemical signatures are becoming more common; however, these instruments provide only presumptive testing and do not stand up to the requirements for admission in court. Analysts presenting testimony in court must present validated results that include the quality control methods used in the lab, calibration and quality control methods performed on the instruments used in the analysis, the education and training of the analyst, and the instrument maintenance and cleaning performed prior to analysis. Instruments used in the field by law enforcement cannot meet these rigorous requirements and thus can only provide presumptive results.

Common Terms

Analysts use a number of terms relating to the chemistry, analysis and reporting of controlled substances. The glossary terms below are from the Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG).

Accuracy - Closeness of agreement between a test result or measurement result and the true value.

Analyst - A designated person who examines and analyzes seized drugs or related materials, or directs such examinations to be done; independently has access to unsealed evidence in order to remove samples from the evidentiary material for examination and as a consequence of such examinations, signs reports for court or other purposes.

Analyte - The component of a system to be analyzed.

Audit - Systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which audit criteria are fulfilled.

Bias - The difference between the expectation of the test results and an accepted reference value.

Blank - Specimen or sample not containing the analyte or other interfering substances.

Byproduct - A secondary or incidental product of a manufacturing process.

Calibration - The act of checking or adjusting (by comparison with a standard) the accuracy of a measuring instrument. Operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication.

Capacity - The amount of finished product that could be produced, either in one batch or over a defined period of time, and given a set list of variables.

Catalyst - A substance whose presence initiates or changes the rate of a chemical reaction, but does not itself enter into the reaction.

Certified reference material (CRM) - Reference material characterized by a metrologically valid procedure for one or more specified properties, accompanied by a certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability.

Chain of custody - Procedures and documents that account for the integrity of a specimen or sample by tracking its handling and storage from its point of collection to its final disposition.

Clandestine - Secret and concealed, often for illicit reasons.

Control - Material of established origin that is used to evaluate the performance of a test or comparison.

Detection limit - The lowest concentration of analyte in a sample that can be detected, but not necessarily quantitated under the stated conditions of the test.

False negative - Test result that states that an analyte is absent, when, in fact, it is present above the established limit of detection for the analyte in question.

False positive - Test result that states that an analyte is present, when, in fact, it is not present or, is present in an amount less than a threshold or designated cut-off concentration.

Finished product - A manufactured product ready for use.

Intermediate - Substance that is manufactured for and consumed in or used for chemical processing to be transformed into another substance.

Limit of quantitation - The lowest concentration of an analyte that can be determined with acceptable precision (repeatability) and accuracy under the stated conditions of the test.

Linearity - Defines the ability of the method to obtain test results proportional to the concentration of analyte.

Pharmaceutical identifiers - Physical characteristics of tablets, capsules or packaging indicating the identity, manufacturer, or quantity of substances present.

Population - The totality of items or units of material under consideration.

Precision - Closeness of agreement between independent test/measurement results obtained under stipulated conditions.

Precursor - A chemical that is transformed into another compound, as in the course of a chemical reaction, and therefore precedes that compound in the synthetic pathway.

Procedure - Specified way to carry out an activity or process.

Proficiency testing - Ongoing process in which a series of proficiency specimens or samples, the characteristics of which are not known to the participants, are sent to laboratories on a regular basis. Each laboratory is tested for its accuracy in identifying the presence (or concentration) of the drug using its usual procedures. An accreditation body may specify participation in a particular proficiency testing scheme as a requirement of accreditation.

Qualitative analysis - Analysis in which substances are identified or classified on the basis of their chemical or physical properties, such as chemical reactivity, solubility, molecular weight, melting point, radiative properties (emission, absorption), mass spectra, nuclear half-life, etc. See also A.2.29 quantitative analysis.

Quantitative analysis - Analyses in which the amount or concentration of an analyte may be determined (estimated) and expressed as a numerical value in appropriate units. Qualitative analysis may take place without quantitative analysis, but quantitative analysis requires the identification (qualification) of the analytes for which numerical estimates are given.

Random sample - The sample so selected that any portion of the population has an equal (or known) chance of being chosen. Haphazard or arbitrary choice of units is generally insufficient to guarantee randomness.

Reagent - A chemical used to react with another chemical, often to confirm or deny the presence of the second chemical.

Repeatability (of results of measurements) - Closeness of the agreement between the results of successive measurements of the same measurand carried out subject to all of the following conditions: the same measurement procedure; the same observer; the same measuring instrument, used under the same conditions; the same location; repetition over a short period of time.

Reproducibility (of results of measurements) - Closeness of the agreement between the results of measurements of the same measurand, where the measurements are carried out under changed conditions such as: principle or method of measurement; observer; measuring instrument; location; conditions of use; time.

Sample - Subset of a population made up of one or more sampling units.

Sampling - Act of drawing or constituting a sample.

Sampling plan - A specific plan which states the sample size(s) to be used and the associated criteria for accepting the lot.

Sampling procedure - Operational requirements and/or instructions relating to the use of a particular sampling plan; i.e., the planned method of selection, withdrawal and preparation of sample(s) from a lot to yield knowledge of the characteristic(s) of the lot.

Sampling scheme - A combination of sampling plans with rules for changing from one plan to another.

Traceability - Ability to trace the history, application or location of that which is under consideration.

Trueness - Closeness of agreement between the expectation of a test result or a measurement result and a true value.

Validation - Confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled.

Verification - Confirmation, through the provision of objective evidence, that specified requirements have been fulfilled.

Resources

Scientific Working Group for the Analysis of Seized Drugs ([SWGDRUG](#))

Bureau of Justice Statistics ([BJS](#))

Drug Enforcement Administration ([DEA](#))

Office of National Drug Control Policy ([ONDCP](#))

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