NEUTRON ACTIVATION ANALYSIS pdf

1: Neutron Activation Analysis at HFIR | Neutron Science at ORNL

Neutron activation analysis (NAA) is a nuclear process used for determining the concentrations of elements in a vast amount of materials. NAA allows discrete sampling of elements as it disregards the chemical form of a sample, and focuses solely on its nucleus.

Overview[edit] Neutron activation analysis is a sensitive multi- element analytical technique used for both qualitative and quantitative analysis of major, minor, trace and rare elements. NAA was discovered in by Hevesy and Levi, who found that samples containing certain rare earth elements became highly radioactive after exposure to a source of neutrons. NAA is significantly different from other spectroscopic analytical techniques in that it is based not on electronic transitions but on nuclear transitions. To carry out an NAA analysis, the specimen is placed into a suitable irradiation facility and bombarded with neutrons. This creates artificial radioisotopes of the elements present. Following irradiation, the artificial radioisotopes decay with emission of particles or, more importantly gamma rays , which are characteristic of the element from which they were emitted. For the NAA procedure to be successful, the specimen or sample must be selected carefully. In many cases small objects can be irradiated and analysed intact without the need of sampling. But, more commonly, a small sample is taken, usually by drilling in an inconspicuous place. This will reveal any contamination of the sample from the drill bit material itself. The sample is then encapsulated in a vial made of either high purity linear polyethylene or quartz. The sample and a standard are then packaged and irradiated in a suitable reactor at a constant, known neutron flux. A typical reactor used for activation uses uranium fission , providing a high neutron flux and the highest available sensitivities for most elements. These neutrons are termed thermal neutrons. Upon irradiation, a thermal neutron interacts with the target nucleus via a non-elastic collision, causing neutron capture. This collision forms a compound nucleus which is in an excited state. The excitation energy within the compound nucleus is formed from the binding energy of the thermal neutron with the target nucleus. This excited state is unfavourable and the compound nucleus will almost instantaneously de-excite transmutate into a more stable configuration through the emission of a prompt particle and one or more characteristic prompt gamma photons. In most cases, this more stable configuration yields a radioactive nucleus. The newly formed radioactive nucleus now decays by the emission of both particles and one or more characteristic delayed gamma photons. This decay process is at a much slower rate than the initial de-excitation and is dependent on the unique half-life of the radioactive nucleus. These unique half-lives are dependent upon the particular radioactive species and can range from fractions of a second to several years. Once irradiated, the sample is left for a specific decay period, then placed into a detector, which will measure the nuclear decay according to either the emitted particles, or more commonly, the emitted gamma rays. The kinetic energy of the neutrons used for irradiation will be a major experimental parameter. Medium KE neutrons may also be used for activation, these neutrons have been only partially moderated and have KE of 0. High KE neutrons are sometimes used for activation, these neutrons are unmoderated and consist of primary fission neutrons. Another major experimental parameter is whether nuclear decay products gamma rays or particles are measured during neutron irradiation prompt gamma , or at some time after irradiation delayed gamma, DGNAA. PGNAA is generally performed by using a neutron stream tapped off the nuclear reactor via a beam port. Neutron fluxes from beam ports are the order of times weaker than inside a reactor. This is somewhat compensated for by placing the detector very close to the sample reducing the loss in sensitivity due to low flux. PGNAA is generally applied to elements with extremely high neutron capture cross-sections ; elements which decay too rapidly to be measured by DGNAA; elements that produce only stable isotopes ; or elements with weak decay gamma ray intensities. PGNAA is characterised by short irradiation times and short decay times, often in the order of seconds and minutes. DGNAA is applicable to the vast majority of elements that form artificial radioisotopes. DG analyses are often performed over days, weeks or even months. This improves sensitivity for long-lived radionuclides as it allows short-lived radionuclide to decay, effectively eliminating interference. DGNAA is characterised by long irradiation times and long decay times, often in the order of hours, weeks or longer. The sample can be placed in an irradiation

container which is then placed in the reactor; if epithermal neutrons are required for the irradiation then cadmium can be used to filter out the thermal neutrons. The advantages of this kind of apparatus is that it is compact, often benchtop-sized, and that it can simply be turned off and on. A disadvantage is that this type of source will not produce the neutron flux that can be obtained using a reactor. Isotope sources[edit] For many workers in the field a reactor is an item which is too expensive, instead it is common to use a neutron source which uses a combination of an alpha emitter and beryllium. These sources tend to be much weaker than reactors. Gas discharge tubes[edit] These can be used to create pulses of neutrons, they have been used for some activation work where the decay of the target isotope is very rapid. For instance in oil wells. Most are designed to detect the emitted gamma radiation. The most common types of gamma detectors encountered in NAA are the gas ionisation type, scintillation type and the semiconductor type. Of these the scintillation and semiconductor type are the most widely employed. The planar detector has a flat, large collection surface area and can be placed close to the sample. Scintillation-type detectors use a radiation-sensitive crystal, most commonly thallium-doped sodium iodide NaI Tl , which emits light when struck by gamma photons. These detectors have excellent sensitivity and stability, and a reasonable resolution. Semiconductor detectors utilise the semiconducting element germanium. The semiconducting element silicon may also be used but germanium is preferred, as its higher atomic number makes it more efficient at stopping and detecting high energy gamma rays. Both Ge Li and HPGe detectors have excellent sensitivity and resolution, but Ge Li detectors are unstable at room temperature, with the lithium drifting into the intrinsic region ruining the detector. The development of undrifted high purity germanium has overcome this problem. Gamma rays, however, are not absorbed or attenuated by atmospheric gases, and can also escape from deep within the sample with minimal absorption. Analytical capabilities[edit] NAA can detect up to 74 elements depending upon the experimental procedure, with minimum detection limits ranging from 0. Heavier elements have larger nuclei, therefore they have a larger neutron capture cross-section and are more likely to be activated. Some nuclei can capture a number of neutrons and remain relatively stable, not undergoing transmutation or decay for many months or even years.

NEUTRON ACTIVATION ANALYSIS pdf

2: Neutron Activation Analysis Evidence in the JFK Assassination

Neutron activation analysis (NAA) is a nuclear process used for determining the concentrations of elements in a vast amount of www.enganchecubano.com relies on excitation by neutrons so that the treated sample emits gamma-rays.

Possible Applications for NAA Archaeology The use of neutron activation analysis to characterize archaeological specimens e. Over the past decade, large databases of chemical fingerprints for clays, obsidian, chert and basalt have been accumulated through analysis of approximately thirty elements in each of more than 42, specimens. The combination of these databases with powerful multivariate statistical methods i. The sourcing information can help archaeologists reconstruct the habits of prehistoric peoples. For example, the "fingerprinting" of obsidian artifacts by NAA is a nearly percent successful method for determining prehistoric trade routes since sources of obsidian are easily differentiated from one another through their chemical compositions. Soil Science Many agricultural processes and their consequences, such as fertilization and herbicidal and pesticidal control, are influenced by surface and sub-surface movement, percolation and infiltration of water. Stable activatable tracers, such as bromide, analyzed by NAA, have allowed the soil scientist to quantify the distribution of agricultural chemicals under a wide variety of environmental and land use influences. In soil science ca. KBr, NaBr, SrBr2 was introduced as a non-reactive stable tracer in solute transport studies normally moving freely with the flux of water without substantial chemical or physical interactions with the soil. Where the sensitivity is adequate, the selective conductivity method, which is simple, affordable and fast, is preferred. We investigated the use of epithermal neutron activation analysis ENAA as a means of measuring Br- directly in soil samples without an extraction. ENAA was chosen because of its high theoretical advantage factor over aluminum i. Geology Analysis of rock specimens by neutron activation analysis assists geochemists in research on the processes involved in the formation of different rocks through the analysis of the rare earth elements REEs and other trace elements. About 30 elements can be measured routinely in almost any geological sample. An additional elements can be measured by applying specialized procedures. In addition to modeling geochemical processes, other applications include location of ore deposits and tracking elements of environmental importance. For example, the discovery of anomalously high iridium concentrations in million-year old limestone deposits from Italy and Denmark could only have been accomplished by NAA. The NAA findings support the theory that extinction of the dinosaurs occurred soon after the impact of a large meteorite with the earth. Environmental Analysis Study of Uranium and Thorium Redistribution due to Ore Processing In the 10 years between and uranium ore mining in the United States expanded from a cumulative total of 38, tons to 5. Ores from these mines were chemically processed at an estimated 50 to sites. These activities have resulted in the contamination of hundreds of square miles of surface and subsurface soils, and their corresponding ground waters, with uranium, thorium and their radioactive daughters. In most cases these sites have various radioactive waste materials such as ore tailings, processing residues and leachates mixed with soil and generally covered with an uncontaminated soil layer several feet in thickness. In other cases the tailings or wastes have remained exposed and hence have been further distributed by wind and erosion. EBNAA has been developed as a methodology suitable for automation by which contaminated ore-processing sites can be characterized and their restoration monitored. Selenium Distribution in Aquatic Species in Selenium-Contaminated Fresh-water Impoundments This work is being done in collaboration with both federal and state agencies. Fresh-water ecosystems in California have been grossly contaminated with selenium as a result of irrigation run-off from heavily used agricultural areas. The effect has been observed throughout most of the food chain. The objective of these studies is to evaluate the extent of the contamination and evaluate methodologies that might be efficacious in the reduction of selenium in these ecosystems. An Emerging Waste Management Technology With an increasing emphasis being placed on the cleanup of hazardous waste sites from past technological operations, science has had to come up with ideas on how to simultaneously decompose and stabilize a variety of mixed wastes which include radioactive materials. The most difficult of all wastes to cleanup is mixed waste. These may contain organic materials dichlorobenzene, naphthalene, etc along with hazardous elements cadmium,

mercury,plutonium, thorium, uranium and other transuranics. Current waste destruction technology relies on oxidation of the waste incineration ; an alternative is the storage of this waste. Incineration requires high temperatures and the resulting high fuel costs and volatilization of some hazardous components. Storage costs are proportional to the amount of space taken up by the waste and the regulations surrounding the waste, therefore, long term storage of some existing radioactive waste is unacceptable without volume reduction and stabilization. A process developed at MU, ChemChar gasification, helps minimize these problems. ChemChar gasification using a coal char a triple reverse burn coal product which is very porous acts as both a surface for chemical reactions and a sequestering agent of hazardous elements. Initially the process uses the char as an absorber of the waste stream which is mixed on a 2: A flame front is established which moves opposite the direction of oxygen flow and in the flame front organics are decomposed and other species tend to be chemically reduced. The volatile organics are carried off and trapped later while the immobile metals, metalloids and some non-metals are sequestered on the char for final disposal or other disposition. The gasification process also results in volume reduction, partitioning of potentially usable organic solvents and the production of a gas that could be used as an energy source. The objective of the MURR component of this project is to develop a procedure by which radiotracers can be used to determine the fates of hazardous elements during gasification in support of the use of gasification as a means of decomposing, stabilizing and reducing the volume of hazardous mixed wastes including radioactive wastes resulting from the nuclear weapons program. To date the fates of arsenic, strontium, cadmium, cesium, mercury, uranium, thorium, neptunium and protactinium, chlorine as an organochloride and phosphorus as organophosphorus surrogates for military wastes have been studied in this reducing atmosphere using MURR produced radiotracers. The behavior of semiconductor devices is strongly influenced by the presence of impurity elements either added intentionally doping with B, P, As, Au, etc. Small quantities of impurities present at concentrations below 1 ppb can have a significant effect on the quality of semiconductor devices. The objective of the client is to demonstrate that a chemical or material meets or exceeds purity requirements required by the end user. In some instances the MURR Nuclear Analysis Group conducts a multi-element qualitative and quantitative analysis which then is used as the certificate of analysis for that substance. In other cases the NA staff work with clients to establish purification factors at various stages in the production process of high-purity materials such as silicon or, the efficacy of cleaning and leaching procedures. In still other cases we are ask to demonstrate that a specific impurity or set of impurities is below the level of technical or regulatory concern. NAA is the elemental analysis method of choice for these projects because of the limited sample handling required and the high sensitivity for many elements of interest. This work has been done in collaboration with several pharmaceutical companies and university research centers. The in-situ radiotracers are produced through carefully designed irradiations done at the MURR and used in laboratory, animal, and in a few cases, human experiments. These methodologies offer significant advantages in the evaluation of encapsulations, time release, clearance and the distribution of the pharmaceutical in animal and human models. One specific aim of the project is to evaluate the relationship between selenium status and cancer of the colon and prostate in the Physicians Health Study. As proposed, this is a five-year study using prospectively collected blood samples as the biologic monitor of selenium status. If fully funded, this would be the largest prospective case-control study to date of selenium status and incidence of prostate cancer. Over the five years prostate cancer cases and colon cancer cases are anticipated. Suspected selenium determinants such as smoking, use of dietary supplements, age and gender will be statistically evaluated in a population of over subjects. Results will be compared with our earlier study of a female population drawn from 11 states in the U. The objective of this work is to expand the collaborative MURR nutritional epidemiology program, that has enjoyed good success in the U. This pilot will serve as a basis for two grant applications that will be submitted to the National Cancer Institute of Canada and the Canadian Research Council. The work is being done in collaboration with the Faculty of Medicine, University of Toronto. Asian women who have immigrated to the U. Specifically, iodine intake is substantially increased and may stress a hypersensitive thyroid --a condition observed in many of these subjects presumably due to chronically low iodine intakes prior to immigration. MURR is responsible for two specific aims: In these subjects, the use of iodine-containing contrast agents can

confound analytical interpretations of any biologic monitor. From our work we have found that biologic monitors from subjects exposed to iodine-containing contrast agents will be influenced by the exposure for over a year. Consequently, these subjects should be screened out of nested case-control studies having an iodine hypothesis. The case-control comparison is blinded to our laboratory and will be evaluated beginning in There is some evidence that higher than normal intakes of arsenic may increase the risk of non-melanoma skin cancer. This hypothesis is being studied in a New Hampshire population routinely ingesting comparatively high levels of arsenic in their drinking water supplies which are typically wells serving a single residence or just a few residences. We have shown that the arsenic concentration in nails is directly correlated with drinking-water arsenic levels. An NAA procedure to measure arsenic in nails has been developed and applied in this nested pseudo-prospective case-control study. Over samples have been analyzed over the last 2 years which is approximately the midpoint of the project. The case-control status will remain blind to our laboratory until the project is concluded. Molecular Epidemiology of Prostate Cancer In this study, being conducted in collaboration with Johns Hopkins University, School of Hygiene and Public Health, we are investigating the relationship of dietary and occupational exposures to selenium, cadmium and zinc and the incidence of prostate cancer. This is the most extensive study to date in which we have the opportunity to compare two biologic monitors, nails and blood sera or plasma, in a nested case-control study having a specific disease outcome. NAA was also used to measure mineralization differences in the whole-body of the CF and normal mouse. In support of human studies with low birth-weight infants, juvenile rheumatoid arthritics and cystic methodology, based on stable isotopes measured via NAA, has been developed to measure true absorption of calcium from experimental diets.

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3: Neutron Activation Analysis - Analytical Chemistry Group

Neutron Activation Analysis (NAA) is a sensitive analytical technique useful for performing both qualitative and quantitative multi-element analysis of major, minor, and trace elements in samples from almost every conceivable field of scientific or technical interest.

They displayed variable concentrations of antimony within a batch, in contrast to his samples of other bullets, in which the concentration of antimony is consistent within a batch. The amount of antimony is consistent within each Mannlicher Carcano bullet. You simply do not find a wide variation in composition within individual WCC Mannlicherâ€"Carcano bullets, but you do find wide compositional differences from bullet to bullet for this kind of bullet lead. Thus, when you find two specimens that agree this closely, you can say it looks indeed like they are pieces from the same bullet. The single bullet theory was substantiated by the findings of a neutron activation analysis performed for the committee. Neutron activation analysis showed no evidence of a third bullet among those fragments large enough to be tested. The second gunman is supposed to have fired from the grassy knoll , missing his target. The acoustical evidence is not universally accepted; for a readable overview, see G. Paul Chambers, , Prometheus Books, , pp. Journal of Forensic Sciences , vol. Sheather, Stuart Wexler and D. Is a Second Shooter Possible? Random matches to assassination fragments of bullets from the same box are not as rare as Dr Guinn testified. Spiegelman et al, op. We then analyzed 10 bullets from each box. The measurement approach was similar to that used by Dr Guinn except that we used more appropriate standards, a known quality control procedure, and analyzed physical samples having a known geometry. One of the bullets analyzed matched an assassination fragment. Supplies of bullet lead come mostly from recycled car batteries, and contain trace quantities of elements such as copper, tin, arsenic and antimony in varying amounts. The manufacturing process for bullets without copper or steel jackets includes a tightly controlled extra amount of antimony, usually comprising up to five percent of the alloy, which hardens the lead sufficiently to allow the bullets to function without a jacket. Each bullet contained an almost identical proportion of antimony to lead. Guinn noted the variable proportions of antimony in the JFK bullet fragments, and mistakenly assumed that this variability was a feature of that brand of bullet. In fact, it is a feature of all types of jacketed bullets. He also claimed that the antimony within an individual bullet is distributed evenly. This was not in fact true of the WCC bullets, in which antimony tends to be concentrated around crystals of lead. Bullet Fragments and NAA Fragments which contain similar levels of antimony may come from one bullet, but may instead come from several bullets. Fragments which contain differing levels of antimony could come from several bullets, but may instead come from different areas within one bullet. In short, neutron activation analysis cannot be used to determine the origin of bullet fragments. The technique is no longer used by the FBI for this purpose. The absence of damage to the base of CE makes it extremely unlikely that the fragments of lead came from that bullet, which in any case appears to have been entered into evidence fraudulently at a later date. Such a bullet could not have been associated with any of the shells found in the TSBD. Again, the implication is that more than one gunman was involved. Edgar Hoover explained in a letter to J. Neutron activation is a sensitive analytical technique to determine elements present in a substance. During the course of the spectrographic examinations previously conducted of the fabric surrounding the hole in the front of the shirt, including the tie, no copper was found in excess of that present elsewhere in undamaged areas of the shirt and tie. Therefore, no copper was found which could be attributed to projectile fragments. It is not felt that the increased sensitivity of neutron activation analyses would contribute substantially to the understanding of the origin of this hole and frayed area. In its Report , the Commission mentioned that traces of copper were found by spectroscopic examination around the hole in the back of the shirt, but failed to mention the absence of copper around the slits in the front. It dishonestly left open the possibility that the damage to the front may have been caused by a bullet.

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4: Neutron activation analysis - Wikipedia

Neutron Activation Analysis. Instrumental Neutron Activation Analysis (INAA or NAA) INAA is a method to determine the concentration of trace (1 to ppm), minor (w/o to w/o), and major (w/o and above) elements in a variety of matrices.

Glascock, Senior Research Scientist, University of Missouri Research Reactor Introduction The application of neutron activation analysis NAA to investigate archaeological problems began in the mids, when scientists at Brookhaven National Laboratory Sayre and Dodson recognized its potential for relating artifacts to source materials through their chemical signatures. The advantages of NAA over other analytical techniques were quickly recognized, including: Interest in NAA expanded throughout the s, s, and s as a result of an increased curiosity in archaeological questions by physical scientists e. Neutron Activation Analysis NAA is a sensitive analytical technique useful for performing both qualitative and quantitative multi-element analysis of major, minor, and trace elements in samples from almost every conceivable field of scientific or technical interest. For many elements and applications, NAA offers sensitivities that are superior to those attainable by other methods, on the order of parts per billion or better. In addition, because of its accuracy and reliability, NAA is generally recognized as the "referee method" of choice when new procedures are being developed or when other methods yield results that do not agree. Worldwide application of NAA is so widespread it is estimated that approximately , samples undergo analysis each year. For more information about all analytical services at MURR Neutron activation analysis was discovered in when Hevesy and Levi found that samples containing certain rare earth elements became highly radioactive after exposure to a source of neutrons. From this observation, they quickly recognized the potential of employing nuclear reactions on samples followed by measurement of the induced radioactivity to facilitate both qualitative and quantitative identification of the elements present in the samples. The basic essentials required to carry out an analysis of samples by NAA are a source of neutrons, instrumentation suitable for detecting gamma rays, and a detailed knowledge of the reactions that occur when neutrons interact with target nuclei. Brief descriptions of the NAA method, reactor neutron sources, and gamma-ray detection are given below The NAA Method The sequence of events occurring during the most common type of nuclear reaction used for NAA, namely the neutron capture or n,gamma reaction, is illustrated in Figure 1. When a neutron interacts with the target nucleus via a non-elastic collision, a compound nucleus forms in an excited state. The excitation energy of the compound nucleus is due to the binding energy of the neutron with the nucleus. The compound nucleus will almost instantaneously de-excite into a more stable configuration through emission of one or more characteristic prompt gamma rays. In many cases, this new configuration yields a radioactive nucleus which also de-excites or decays by emission of one or more characteristic delayed gamma rays, but at a much slower rate according to the unique half-life of the radioactive nucleus. Depending upon the particular radioactive species, half-lives can range from fractions of a second to several years. Diagram illustrating the process of neutron capture by a target nucleus followed by the emission of gamma rays In principle, therefore, with respect to the time of measurement, NAA falls into two categories: The latter operational mode is more common; thus, when one mentions NAA it is generally assumed that measurement of the delayed gamma rays is intended. Neutrons Although there are several types of neutron sources reactors, accelerators, and radioisotopic neutron emitters one can use for NAA, nuclear reactors with their high fluxes of neutrons from uranium fission offer the highest available sensitivities for most elements. Different types of reactors and different positions within a reactor can vary considerably with regard to their neutron energy distributions and fluxes due to the materials used to moderate or reduce the energies of the primary fission neutrons. However, as shown in Figure 2, most neutron energy distributions are quite broad and consist of three principal components thermal, epithermal, and fast. A typical reactor neutron energy spectrum showing the various components used to describe the neutron energy regions. The thermal neutron component consists of low-energy neutrons energies below 0. At room temperature, the energy spectrum of thermal neutrons is best described by a Maxwell-Boltzmann distribution with a mean energy of 0. In general, a one-megawatt reactor has a peak thermal neutron flux of approximately 1E13 neutrons per square centimeter per second. The epithermal neutron component consists of

neutrons energies from 0. A cadmium foil 1 mm thick absorbs all thermal neutrons but will allow epithermal and fast neutrons above 0. Both thermal and epithermal neutrons induce n,gamma reactions on target nuclei. An NAA technique that employs only epithermal neutrons to induce n,gamma reactions by irradiating the samples being analyzed inside either cadmium or boron shields is called epithermal neutron activation analysis ENAA. The fast neutron component of the neutron spectrum energies above 0. The PGNAA technique is generally performed by using a beam of neutrons extracted through a reactor beam port. Fluxes on samples irradiated in beams are on the order of one million times lower than on samples inside a reactor but detectors can be placed very close to the sample compensating for much of the loss in sensitivity due to flux. The PGNAA technique is most applicable to elements with extremely high neutron capture cross-sections B, Cd, Sm, and Gd ; elements which decay too rapidly to be measured by DGNAA; elements that produce only stable isotopes; or elements with weak decay gamma-ray intensities. The technique is flexible with respect to time such that the sensitivity for a long-lived radionuclide that suffers from an interference by a shorter-lived radionuclide can be improved by waiting for the short-lived radionuclide to decay. Radiochemical NAA With the use of automated sample handling, gamma-ray measurement with solid-state detectors, and computerized data processing it is generally possible to simultaneously measure more than thirty elements in most sample types without chemical processing. If chemical separations are done to samples after irradiation to remove interferences or to concentrate the radioisotope of interest, the technique is called radiochemical neutron activation analysis RNAA. The latter technique is performed infrequently due to its high labor cost. Most NAA labs operate one or more hyperpure or intrinsic germanium HPGe detectors which operate at liquid nitrogen temperatures 77 degrees K by mounting the germanium crystal in a vacuum cryostat, thermally connected to a copper rod or "cold finger". Although HPGe detectors come in many different designs and sizes, the most common type of detector is the coaxial detector which in NAA is useful for measurement of gamma-rays with energies over the range from about 60 keV to 3. Gamma-ray spectrum showing several short-lived elements measured in a sample of pottery irradiated for 5 seconds, decayed for 25 minutes, and counted for 12 minutes with an HPGe detector. Gamma-ray spectrum from 0 to keV showing medium- and long-lived elements measured in a sample of pottery irradiated for 24 hours, decayed for 9 days, and counted for 30 minutes on a HPGe detector. Gamma-ray spectrum from to keV showing medium- and long-lived elements measured in a sample of pottery irradiated for 24 hours, decayed for 9 days, and counted for 30 minutes on a HPGe dectector. The two most important performance characteristics requiring consideration when purchasing a new HPGe detector are resolution and efficiency. Other characteristics to consider are peak shape, peak-to-Compton ratio, crystal dimensions or shape, and price. In general, detector resolution is specified in terms of the full width at half maximum FWHM of the keV photopeak of Co and the keV photopeak of Co For most NAA applications, a detector with 1. Detector efficiency depends on the energy of the measured radiation, the solid angle between sample and detector crystal, and the active volume of the crystal. A larger volume detector will have a higher efficiency. In general, detector efficiency is measured relative to a 3-inch by 3-inch sodium iodide detector using a Co source keV gamma ray at a distance of 25 cm from the crystal face. A general rule of thumb for germanium detectors is 1 percent efficiency per each 5 cc of active volume. As detector volume increases, the detector resolution gradually decreases. Typical gamma-ray spectra from an irradiated pottery specimen are shown in Figures 3â€”5 using two different irradiation and measurement procedures. If the unknown sample and the comparator standard are both measured on the same detector, then one needs to correct the difference in decay between the two. One usually decay corrects the measured counts or activity for both samples back to the end of irradiation using the half-life of the measured isotope. The equation used to calculate the mass of an element in the unknown sample relative to the comparator standard is: When performing short irradiations, the irradiation, decay and counting times are normally fixed the same for all samples and standards such that the time-dependent factors cancel. Thus the above equation simplifies into: The accuracy of an individual NAA determination usually ranges between 1 to 10 percent of the reported value. Table 1 lists the approximate sensitivities for determination of elements assuming interference free spectra.

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5: Instrumental Neutron Activation Analysis (INAA)

Neutron activation analysis is a method of elemental analysis in which nonradioactive elements are converted to radioactive ones by neutron bombardment, and the elements of interest are determined from resulting radioactivity (Figure 17).

Internal volume for these is 1. Laboratory Equipment PC-based gamma spectrometer, six Germanium detectors four coaxial, one well, one x-ray. A laminar flow hood and glovebox are used to minimize contamination from ambient dust while samples are being prepared. The hood recirculates air through a HEPA filter in the sample preparation region. Liquid scintillation is available for analysis of Beta emitters. Drying oven with entry air filtered through a HEPA filter. Refrigerator for storing critical samples. Accessibility Research and collaboration with Universities and Industry are welcomed. Prospective users are encouraged to contact one of the staff to discuss potential projects, approaches, and arrangements. Some materials are inappropriate for irradiation at HFIR. Among these are liquids generally , materials highly corrosive to stainless steel or aluminum, materials that react violently with water, explosives and highly flammable substances, and materials that pose exceptional danger to humans. If the matrix to be analyzed does not become too radioactive when activated with neutrons, or if the unwanted radioactivity decays quickly, then groups of trace elements can often be measured simultaneously. Examples of multi-element NAA are given below. Forensic Analysis Personnel of the NAA laboratory have considerable experience in the forensic analysis of evidentiary materials. Bullet fragments, gunshot residue, plastic, hair and fingernails, and geological materials are included among recent examples. Comparing materials nondestructively is a chief advantage of NAA for forensics. High-Purity Materials Materials such as high-purity silica, silicon, aluminum, other materials and their compounds that do not form long-lived radionuclides, cellulose air filters, as well as graphite are excellent matrices for high-sensitivity NAA. Such materials can be irradiated in graphite rabbits for many hours in PT-1 for determinations of many elements at the sub-ppb level. Silicon wafers and SiO2 used in fiber optics are examples that have been analyzed. Extremely low quantities of certain elements such as Ir can be measured utilizing microwave digestion facilities available at ORNL and straightforward chemical separation techniques. Operating Status As of Startup plans for cycle B will be communicated as they become known.

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6: Neutron Activation Analysis | Definition of Neutron Activation Analysis by Merriam-Webster

Neutron activation analysis is a method for the qualitative and quantitative determination of elements based on the measurement of characteristic radiation from radionuclides formed by irradiating materials by neutrons.

This website is not being updated anymore. Neutron Activation Analysis Techniques and the facilities where you can find them Overview NAA - Neutron Capture Neutron capture Neutron activation analysis NAA is a nuclear process used for determining the concentrations of elements in a vast amount of materials. NAA relies on excitation by neutrons so that the treated sample emits gamma-rays. It allows the precise identification and quantification of the elements, above all of the trace elements in the sample. NAA has applications in chemistry but also in other research fields, such as geology, archeology, medicine, environmental monitoring and even in the forensic science. The method is based on neutron activation and therefore requires a source of neutrons. The sample is bombarded with neutrons, causing the elements to form radioactive isotopes. The radioactive emissions and radioactive decay paths for each element are well known. Using this information, it is possible to study spectra of the emissions of the radioactive sample, and determine the concentrations of the elements within it. A particular advantage of this technique is that it does not destroy the sample, and thus has been used for analysis of works of art and historical artifacts. NAA was used to learn how to go from ash to eco-friendly solution for hazardous metals removal. Click to know more! Neutron Activation Analysis is very sensitive and is therefore used to analyse for minor elements, which are present in very low concentrations. The method is especially useful for trace element analysis, e. It can also be used to detect trace element in water, biological material and minerals. It is usually used as an important reference for other analysis methods. Some nuclei can capture a number of neutrons and remain relatively stable, not undergoing transmutation or decay for many months or even years. Different nuclei have different cross sections and half lives, and the intensities of the emitted gamma-rays can also vary â€” therefore the detection limits are quite variable. The PGAA technique is generally performed by using a beam of neutrons extracted through a reactor beam port. Fluxes on samples irradiated in beams are in the order of one million times lower than on samples inside a reactor but detectors can be placed very close to the sample compensating for much of the loss in sensitivity due to flux. The PGAA technique is most applicable to elements with extremely high neutron capture cross-sections B, Cd, Sm, and Gd ; elements which decay too rapidly to be measured by DGAA; elements that produce only stable isotopes e. The technique is flexible with respect to time such that the sensitivity for a long-lived radionuclide that suffers from an interference by a shorter-lived radionuclide can be improved by waiting for the short-lived radionuclide to decay or quite the contrary, the sensitivity for short-lived isotopes can be improved by reducing the time irradiation to minimize the interference of long-lived isotopes. Where to find this technique? PGAA can be found at:

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7: Neutron Activation Analysis

Neutron activation analysis sensitivities and accuracy are dependent on the concentration of a particular element and radionuclide parameters (i.e., parent isotope abundance, neutron cross-section, half-life, and gamma ray abundance).

Click image to enlarge. Details Instrumental neutron activation analysis INAA is used to determine the concentration of trace and major elements in a variety of matrices. A sample is subjected to a neutron flux and radioactive nuclides are produced. As these radioactive nuclides decay, they emit gamma rays whose energies are characteristic for each nuclide. Comparison of the intensity of these gamma rays with those emitted by a standard permit a quantitative measure of the concentrations of the various nuclides. Details 58Fe is a stable isotope of iron while 59Fe is a radioactive isotope. The gamma rays emitted during the decay of the 59Fe nucleus have energies of The probability of a neutron interacting with a nucleus is a function of the neutron energy. This probability is referred to as the capture cross-section, and each nuclide has its own neutron energyâ€"capture cross-section relationship. For many nuclides, the capture cross-section is greatest for low energy neutrons referred to as thermal neutrons. Some nuclides have greater capture cross-sections for higher energy neutrons epithermal neutrons. For routine neutron activation analysis we are generally looking at nuclides that are activated by thermal neutrons. From this equation we can see that the total activity for a particular nuclide is a function of the activation cross-section, the neutron flux, the number of parent atoms, and the irradiation time. Note that for any particular radioactive nuclide radioactive decay is occurring during irradiation, hence the total activity is determined by the rate of production minus the rate of decay. If the irradiation time is much longer than the half-life of the nuclide, saturation is achieved. What this means is that the rate of production and decay is now in equilibrium and further irradiation will not lead to an increase in activity. The optimum irradiation time depends on the type of sample and the elements of interest. Because the neutron flux is not constant, the total flux called fluence received by each sample must be determined using an internal or external fluence monitor. It is sometimes useful to convert from half-life to decay constant. After the sample has been activated, the resulting gamma ray energies and intensities are determined using a solid-state detector usually Ge. Gamma rays passing through the detector generate free-electrons. The number of electrons current is related to the energy of the gamma ray. Because there can be thousands to hundreds of thousands of gamma ray interactions per second with the detector, an important criteria in system design is the response time of the detector to gamma ray interactions as measured by the dead time. Each radioactive nuclide is also decaying during the counting interval and corrections must be made for this decay. When subjected to a thermal neutron flux U atoms in a sample will undergo fission producing a variety of fission products, some of which are nuclides of interest. Hence, a correction that must be made, when U is present, is for the amount of a nuclide produced by the fission process. Given the differences in half-lives for various nuclides, there are optimum times to count an activated sample. In general nuclides with relatively short half-lives, on the order of hours to days, are determined within the first week of irradiation. Nuclides with half-lives on the order of weeks to months are determined 4 to 8 weeks after irradiation. Hence, activated samples are counted several times after irradiation. A gamma-ray spectroscopy system consists of a detector and high voltage power supply for the detector , pre-amplifier, spectroscopy amplifier, analog-to-digital converter, multi-channel analyzer, and an output device. A sample is presented to the detector Ge in the case of gamma-ray analysis. The initial signal is very small and the pre-amplifier, attached directly to the detector, amplifies this signal. The signal is shaped by the spectroscopy amplifier and then converted from an analog to a digital signal by the analog-to-digital converter. The results are stored in digital form multi-channel analyzer. In modern gamma-ray spectroscopy systems the high-voltage power supply, spectroscopy amplifier, analog-to-digital converter, and multi-channel analyzer are combined into a single module. Flow chart for a gamma-ray spectroscopy system. Details A computer is used to visually show the resulting spectrum and to do calculations on the spectrum. Various algorithms are used to determine the shape and energy of each gamma-ray peak present in a spectrum and to determine the area encompassed by the peak i. Subsequent decay, interference if required , fluence, fission product corrections, and comparison with a standard lead to a

quantitative analysis. Hide Gamma-ray spectroscopy system automated sample changer. The detector is kept at liquid nitrogen temperatures dewer under cave. The small box on top of the cabinet combines all the functions of the HV power supply, spectroscopy amplifier, and analog-to-digital converter. The resultant spectrum is shown on the computer screen. Details Applications While liquid samples if certain precautions are taken can be analyzed by INAA, solids are the matrix of choice for this technique. Virtually any material can be analyzed and limitations are largely due to the chemistry of the matrix. For example, it would be difficult to obtain low detection limits for a sample of pure iron because given the half-life Examples of the types of materials that can be analyzed by INAA are: Rocks, minerals, and soils.

8: Neutron Activation & Elemental Analysis | MIT Nuclear Reactor Laboratory

Neutron activation analysis, discovered in , stands at the forefront of techniques used for quantitative multi-element analysis of major, minor, trace, and rare elements. NAA allows the measurement of ~60 elements in small samples.

9: Neutron Activation Analysis - Nuclear Reactor Program

Neutron Activation Analysis (NAA) is one of the most sensitive methods used to measure the concentration of trace amounts of many elements in a variety of sample types. In NAA, a sample is bombarded with neutrons, resulting in the production of a radioactive isotope of the element of interest.

NEUTRON ACTIVATION ANALYSIS pdf

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