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Neutron activation analysis: an alternative method to perform clinical examination of urine

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This paper reports the application of neutron activation analysis (NAA) to identify and to determine the concentration of Na, K, and Cl present in urine samples. For this investigation, urine samples of Beagles were used. These animals were chosen because 90% of their physiological characteristics are similar to those in humans [1]. The experiments were perform at the facilities of the UNITOX laboratory from the Universidade Santo Amaro (UNISA). The biological samples of urine from four male Beagles dogs were collected weekly during one month and were analyzed by using neutron activation analysis (NAA) and also the conventional clinical analysis: selective electrode, colorimetry and flame spectrometry. For NAA, a GMX2020 HPGe detector connected to a S-100 multichannel analyser and to a PC computer was used to measure the induced γ-ray activity. This procedure was made to identify and quantify the radioactive nuclides ^{38}Cl ($T_{1/2}$=37.29 min, E_γ=1642.0 keV), ^{42}K ($T_{1/2}$=12.52 h, E_γ =1524.70 keV),^{24}Na ($T_{1/2}$=15h, E_γ =1368.4 keV). To determine the concentration of the elements Cl, K and Na, in the urine sample, aliquots of 100 μl of the sample were pipetted onto 1 cm^2 pieces of Whatman N^o 40 filter paper, that were sealed in polythylene bags As standards, convenient aliquots of standard solutions of Na, Cl, and K were prepared in a similar way as the samples. Samples and standards were irradiated for 15 minute in the IEA - R1m reactor of IPEN/SP, in a thermal neutron flux of 10^{13} n/cm^{2}s. After irradiation, the sample and standard were γ-counted for one 10 minutes and the area of the select γ-ray were obtained by using the VISPECT program [2]. The concentration of the elements was obtained using the comparative neutron activation analysis. In tables I, II and III the results of urine sediment quantitative using NAA are presented and compared with the conventional clinical analysis.

Table I. Concentration of Sodium in the urine samples of the Beagles by NAA and by the conventional analysis.

NAA mg/ml	Selective electrode mg/ml	Flame Spectrometry mg/ml
2.53 ± 0.03	2.46 ± 0.11	2.54 ± 0.25
3.40 ± 0.04	3.19 ± 0.12	3.08 ± 0.27
3.59 ± 0.04	3.44 ± 0.14	3.37 ± 0.29
3.31 ± 0.07	3.38 ± 0.13	3.30 ± 0.22

Table II. Concentration of Potassium in the urine sample of the Beagles by NAA and by the conventional analysis.

NAA mg/ml	Selective electrode mg/ml	Flame spectrometry mg/ml
2.24 ± 0.26	2.72 ± 0.18	2.01 ± 0.25
2.85 ± 0.25	2.89 ± 0.19	3.11 ± 0.31
4.30 ± 0.31	3.89 ± 0.30	4.00 ± 0.33
1.60 ± 0.06	1.11 ± 0.10	nd

Table III. Concentration of Chlorine in the urine sample of the Beagles by NAA and by the conventional analysis.

NAA mg/ml	Selective electrode mg/ml	Colorimetry mg/ml
3.11 ± 0.15	2.97 ± 0.29	3.19 ± 0.18
1.86 ± 0.09	1.79 ± 0.13	1.17 ± 0.15
4.40 ± 0.22	3.56 ± 0.31	3.98 ± 0.14
6.40 ± 0.19	6.80 ± 0.24	6.01 ± 0.12

According to these tables, the results of nuclear analysis are consistent with the conventional clinical analysis, so this method can be used to perform clinical examination of urine, concerning the Na, K and Cl levels. Regarding the use of this method we could point out the following advantages: it is an alternative method to diagnose

kidney anomalies; use of small quantities (~100 μl) in comparison with the conventional clinical analysis (~3ml); simultaneous evaluation of chlorine, sodium and potassium concentrations in urine samples, what is not always possible in the conventional analysis (Colorimetry and Flame Spectrometry); low activity (0.1 μCi), which reduces the radiation exposure during the handling process of the active material; due to the short time irradiation and short half-life, associated to the measured radioisotopes (^{38}Cl, ^{24}Na and ^{42}K), there is no residual activity in the urine sample after 48 hours. Regarding the disadvantages of using a nuclear method, two points must be considered: the need of technician experienced with radiological protection to perform the analysis and the necessity of a nuclear reactor; however, a small size prototype of neutron irradiator for clinical analysis is being developed, so that it can be used outside the reactor premises.

References
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Scintillation Light from Microstructure Detectors

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It has been pointed out in previous works [1],[2], that scintillation light emitted in microstructure based gaseous detectors (microstrips, microgaps, GEMs, etc.) can be used for non destructive testing of these detectors when they are associated to a CCD readout system. In the present work we report on a systematic study for several gas mixtures which includes measurements of the total light yields as a function of the electric field and of the spectrometric distribution of the light emitted, in the wavelength region between 250 and 930 μm.

The experimental results presented in this work were performed for three different electric field configurations: a GEM detector, a parallel plane chamber and a scintillation counter with a spherical anode.

A. Light measurements with the GEM detector

The experimental set-up is described in detail in [2]. A Quantix 1400 camera, manufactured by Photometrics Ltd, was used for the readout of the scintillation emitted from the GEM. The chamber was irradiated by an X-ray generator with a molybdenum tube and the gases, high purity research grade, are supplied to the chamber through stainless steel pipes without any additional purification.

B. Light measurements with the PPC

The parallel plate chamber consists of two parallel grids 0.35 *cm* apart. X-ray photons from an X-ray generator are used as excitation source. The tube is operated at about 10 *kV*, with a copper target. The light emitted is collected through a mylar window and detected by a UDT planar-diffused silicon photodiode (PIN-25DP). Long-pass colour glass filters are used to select the wavelength cut off. Current in the chamber was measured with a 610R Keithley electrometer and the photodiode was fed to an amplifier. The gases flow continuously, at atmospheric pressure, through calibrated flowmeters and the detector.

C. Light studies with the GSPC

The scintillation detector has a 3 *mm* diameter stainless steel spherical anode and is described in detail elsewhere [3]. The gas chamber is coupled, through Spectrosil A windows (without wavelength shifter), from one side to a 56 TUVP photomultiplier, having a S20 response, and from the other side to an Applied Photophysics monochromator, mod. 7300, equipped with a 1200 *g/mm* grating, blazed at 500 *nm*. The light analysed by the monochromator is detected by a second photomultiplier, an RCA C31034A, with a GaAs:CsO photocathode which covers the region between 185 and 930 *nm*. This photomultiplier is cooled to -20°C and is operated in the single photon counting mode.

The 56 TUVP photomultiplier was calibrated using the scintillation of a NaI (Tl) crystal when irradiated with ^{60}Co, ^{137}Cs and ^{22}Na gamma sources. As excitation sources, we used an X-ray photons from a collimated ^{55}Fe source (5.9 *keV*) and alpha particles from an ^{241}Am. Light and charge signals are fed into standard electronic units. All the xenon containing mixtures were kept in a closed gas circuit, at a pressure slightly above atmospheric