Thermoluminescent Dosimetry System for two-dimensional determination of ionizing radiation dose distribution in radiotherapy

OVERVIEW OF RESEARCH FINDINGS

The 2D Thermoluminescent Dosimetry System is composed of thermoluminescent detectors and a TLD foil reader. The thermoluminescent detectors (TLD) take the form of a 0.3 mm thick foil and their maximum dimensions are 200x200 mm^2. Available foils have 2 types of high-sensitivity luminophores: LiF:Mg,Cu,P and $CaSO_4$:Dy. The detectors can be bent, reused, applied for measurements in water and they do not require chemical processing. The 50x55x120 cm TLD foil reader weighs 90 kg. The device has a compact structure and a jack-up hatch. It is movable, integrated with a computer and automatic control system, ergonomic, and easy to use. Its readout frequency is 5 minutes, and the results are available after 2 minutes. The parameters of the system are as follows: maximum resolution – 0.25 mm, measured dose range – 0.1-100 Gy, foil homogeneity – 5% (1SD). Currently there are no similar devices available on the market.

The system could be used by radiotherapy centres equipped in teleradiotherapy and brachytherapy systems. The expected production rate is 1-3 items a year for the reader, several hundred items a year for the detectors. The system will be promoted at training sessions or workshops and via free detector samples. The product is to be sold on a licence basis. The expected price of the reader is EUR 60 000 per item, while the price of the detector is EUR 100 per item.

The Institute has submitted a patent application to the Patent Office of the Republic of Poland, entitled: “Method of producing an ionizing radiation detector.”

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Chromatographic measurement system of helium (He) concentration in groundwater

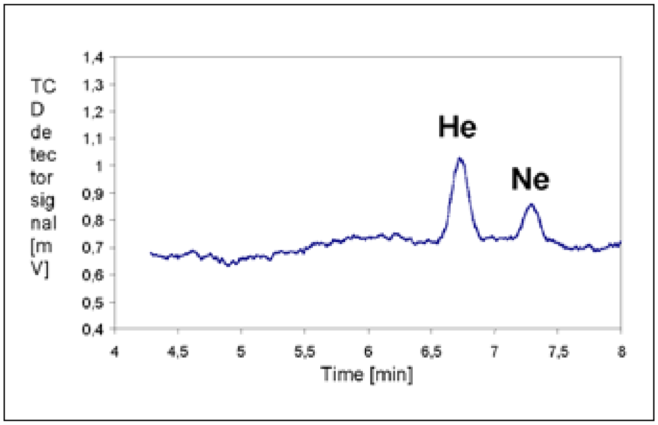
OVERVIEW OF RESEARCH FINDINGS

Studying noble gasses in groundwater yields information about groundwater dynamics, i.e. flow velocities, flow directions, residence times, and recharge rates. It may also point to the environmental conditions under which groundwater infiltrated. Helium (He) concentration in groundwater acts as a fine indicator in water dating.

A chromatographic system for measuring He concentration in groundwater has been developed by the Department of Ecosystems Physicochemistry, Institute of Nuclear Physics. Water samples are collected from groundwater by means of special 2900 cm^3 stainless steel vessels in a manner preventing contamination with air. Helium is extracted from water samples using the headspace method. After its enrichment by the cryotrap method, the He is analysed in a gas chromatograph equipped with a TCD detector with a detection limit of approximately 2.8 ng He. The detection limit of He concentration in water using this method is $0.67 \cdot 10^{-8}$ cm^3 STP/g_{H_2O}.

Gas chromatography (GC) measurements of helium can be used as an alternative to more expensive mass spectrometry (MS) determination of ^{4}He for groundwater dating.

The cost of an analysis carried out by the Institute of Nuclear Physics is EUR 500.



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Magnetic filter-activator to support water deironing and filtration processes, designed for installation in water deironing and water treatment systems before existing iron removers, mechanical filters, or sedimentation tanks

OVERVIEW OF RESEARCH FINDINGS

With an output of 36 m^3/h, dimensions of approx. 1100 mm x 200 mm, and weight of approx. 70 kg, this device is designed for supporting such water treatment processes as: deironing, flocculation, coagulation, sedimentation, and filtration. A magnetic field provokes interfacial chemical reactions in the water-air mixture produced in the device; reactions take place with free radicals and lead to highly efficient oxidation of iron ions present in the water. The latest research findings have confirmed changes in the structure of oxygen molecules in the water after magnetic-field treatment [1]. Simultaneously, a magnetic field activates silicates – always present in each type of natural water [2]. The resulting active silicic acid polycondensates act as very efficient sorbents of iron compounds; they also facilitate flocculation and coagulation of the iron hydroxides produced, which facilitates their removal by filtration and/or sedimentation. This is a very important advantage of the method since iron hydroxides freshly precipitated from water are difficult to coagulate and remove.

Other significant features of the oxidation process in a magnetic field are its speed and efficiency, which largely reduce the need to use expensive storage reservoirs to prolong the reactions occurring during water deironing.

Another advantage of this activator device is that it prevents the precipitation of hard carbonate sediments (calcite) in the system. Using water treated in this manner for capillary watering of plants keeps their capillaries passable without requiring the application of additional chemical substances. Simultaneously, the properties of polysilicates occurring in the water help to stop corrosion processes.

Two such deironing filters were installed in the water deironing installation for plant capillary watering in a large horticultural farm in Sobienie (near Warsaw). The water there was characterized by high fluctuations of total iron content from 3.9 mg/l to 7.8 mg/l. After the installation of a filter-activator with an output of 36 tones/h (as pictured), the concentration of iron in the treated water dropped to 0.4-0.5 mg/l when the iron content in raw water was 3.9 mg/l, and to 0.53-0.76 mg/l when the raw water iron content was 7.8 mg/l. Furthermore, the problem of clogged capillaries disappeared.

Using traditional deironing methods to achieve a similar effect of removing iron compounds from water would entail far greater costs. Additionally, without the use of chemical substances, the device accelerates water conditioning processes (flocculation, coagulation, sedimentation), while slowing down corrosion processes and carbonate sediment precipitation.

The expected production rate should be at least a dozen items a year. The filter will be mostly used in horticultural farms – to treat water in plant capillary watering, water deironing and treatment systems. The magnetic filter-activator is practically operation-free. A patent application was submitted in June 2007.

[1] Ozeki S., Otsuka I. *J. Phys. Chem. B* 2006, *110,* 20067.

[2] Szkatuła A., Bałanda M., Kopec M. *Eur. J. Appl. Phys.*2002, *18,* 41.

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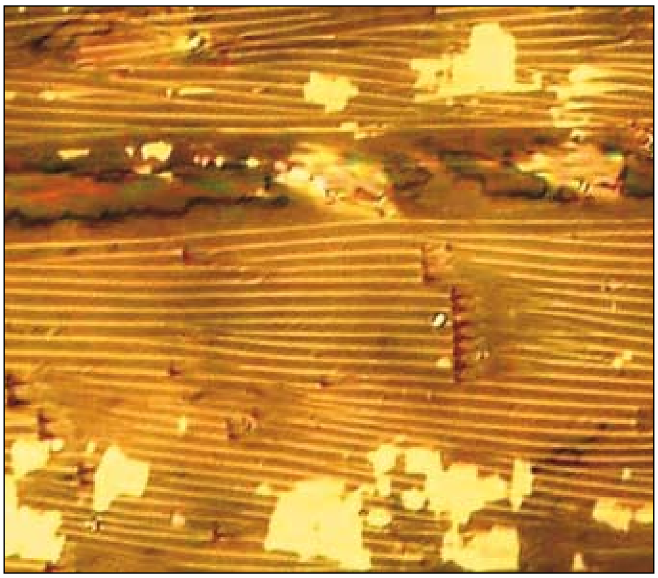
Ferroelectric and antiferroelectricliquid crystals for optoelectronic applications

OVERVIEW OF RESEARCH FINDINGS

The physics of liquid crystals is currently one of the most extensively developing branches of experimental physics. The multitude of phases and phenomena observed in liquid crystals, which is not observed in other materials, is very attractive for scientists. On the other hand, the combination of fluidity and anisotropy of many physical quantities leads material parameters to be very high sensitive to external factors, and this is in turn very attractive for engineers.

From both these standpoints, ferroelectric and antiferroelectric liquid crystals are the most interesting. These materials are the main subject of investigations carried out by the Laboratory of Molecular Interactions at the Institute of Molecular Physics in Poznań. Although these studies do not directly focus on applications, they measure almost all physical parameters important for technicians. The researchers at the Laboratory investigate dielectric properties such as dielectric relaxation, mainly of collective modes. Furthermore, they study spontaneous polarization, helical structure, order parameters, optical properties, and electrooptic phenomena, being of the highest interest to both physicists and engineers. In recent years the Laboratory has succeeded in developing methods to investigate electrooptic effects, enabling the first measurements of absolute values of linear and nonlinear electrooptic coefficients in ferroelectric and antiferroelectric liquid crystals. Simultaneous application of dielectric and electrooptic methods has made it possible to study the mechanisms of the creation of spontaneous polarization in smectic layers. This research has yielded the first credible data concerning flexoelectric polarization in ferroelectric liquid crystals. The knowledge of this polarization component might be of high importance for the development of liquid crystalline displays working in the Deformed Helix Mode (DHM).

The domain structure in a ferromagnetic liquid crystal



Apart from ferroelectric and antiferroelectric liquid crystals, the Laboratory also researches other liquid crystals including so-called “subphases” of antiferroelectric materials. These subphases are still insufficiently understood – it even remains uncertain whether all of them constitute real, thermodynamically stable phases. In many cases their structure is not well-known. The Laboratory studies other chiral liquid crystals, e.g. cholesterics, blue phases, and twist grain boundary phases. Some of them can be considered photonic crystals of different dimensionality (1D, 2D, 3D).

Liquid crystals are used in devices such as displays or monitor screens. Within this group of materials, the antiferroelectric and ferroelectric liquid crystals investigated at the Institute of Molecular Physics are characterized by a number of specific features – especially by high switching speed. Among other achievements, the Institute’s researchers have developed a new method for inducing ferroelectricity in liquid crystals by mixing, developed new methods to measure the material parameters of determining material utility, and explained the mechanism of threshold-less switching in antiferroelectric crystals.

These methods are protected by the following patents: European Patent No. 86850353.3 "Fast switching, low temperature ferroelectric liquid crystal mixtures"; United States Patent No. 4 838663 "Device for submicrosecond electrooptic modulation in the liquid crystal smectic A phase using orthogonal bookshelf geometry."

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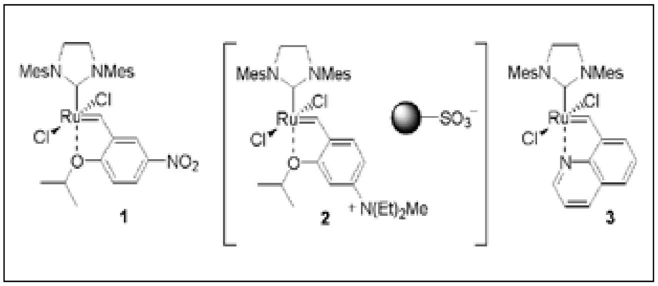
New ruthenium complexes as olefin metathesis catalysts

OVERVIEW OF RESEARCH FINDINGS

Recent decades have seen a burgeoning of interest in the olefin metathesis, as witnessed by a rapidly growing number of elegant applications. Using this tool, chemists can now efficiently synthesize an impressive range of molecules that only a decade ago required significantly longer and tedious routes. The development of efficient and selective ruthenium catalysts, especially, has been the key to the widespread application of olefin metathesis in organic synthesis. Since 2002, we have been developing new catalysts for this transformation (for further reading, see the following review article: K. Grela, A. Michrowska, M. Bieniek. *Chem. Rec.* **2006**, *6*, 144 and literature cited therein). Catalyst 1, (U.S. Patent 6,867,303) has already found several applications in both academic and industrial laboratories, including Boehringer-Ingelheim GmbH. Polymer 2 (*J. Am. Chem. Soc.* **2006**, *128*, 13261) is a highly active catalyst, particularly in cross-metathesis reactions, as used, for example, in the preparation of some steroidal inhibitors of 17β-hydroxysteroid dehydrogenase type 1, useful in the treatment of estradiol-dependent diseases like breast cancer or endometriosis (Solvay Pharmaceuticals, in cooperation with Prof. Andreas Kirschning, unpublished data). Catalyst 3 (*Organometallics* **2006**, *25*, 3599) will be commercialised soon. Subsequent catalysts are currently being developed in close cooperation with Degussa AG and other commercial and academic partners. Some of our catalysts and their applications have been reviewed in a number of journals (A. M. Thayer, *Chemical & Engineering News* **2007**, *85*(07), 37 and Y. Schrodi, R.L. Pederson, *Aldrichimica Acta*, **2007**, *40*(02), 45).

The major drawback of the method is the high catalyst loading needed to perform most metathesis reactions and its toxicity (a review: Clavier H.; Grela K.; Kirschning A.; Mauduit M.; Nolan S. P., *Angew. Chem., Int. Ed.* in press, doi: 10.1002/anie.200605099). Our catalysts can be used in smaller quantities and more easily removed/recycled. Another major hurdle to the implementation of the metathesis reaction in the industry is the near monopoly held on the technology by the California Institute of Technology (Caltech). This monopoly, however, has recently been broken by the development of alternative architectures (such as complex 1 of Figure 1 and others). The competition is fierce as American groups try to maintain their predominance and Chinese groups, like Zannan Pharma, are rapidly catching up. We expect that our research should make a significant scientific and commercial impact. To this end, we are constantly seeking industrial partners interested in the further development and commercialization of our catalysts, and application groups planning to expand the scope of the technology to polymer, fine chemicals and pharmaceutical areas.



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