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Enantiometric Purity Determination to 1% Level Using a Laser-Based Polarimetric HPLC Detector

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leads to local heating of the solvent which in turn leads to a refractive index change in the beam/sample interaction volume. For most solvents the change in refractive index with temperature is negative ($-\mathrm{d}n/\mathrm{d}T$) which causes the solution to behave as a diverging lens. For a gaussian beam profile this causes a reduction in beam intensity at the beam centre which can be monitored in the far field of the thermal lens using a pinhole aperture and photomultiplier detector. The thermal lens signal, θ is related to the absorbance of the chromophore through the following equation

$$\theta = -2.303\,P(\mathrm{d}n/\mathrm{d}T)\,A/\lambda k.$$

The sensitivity of the technique is therefore power dependent, P being the power of the pump beam, λ the laser wavelength, k the thermal conductivity of the solution and A the absorbance of the solution. The technique can be used to gain the same information as conventional UV/visible spectrophotometry but limits of detection are improved by as much as three orders of magnitude because of the power enhancement factor. The determination of $\mathrm{U^{VI}}$ and $\mathrm{Cu^{II}}$ in solution was described using a novel mode-mismatched two beam thermal lens spectrometer. Absorption coefficient detection limits of 10^{-4} and $10^{-7}\ \mathrm{cm^{-1}}$ for these species were found in nanolitre volumes of solution.

The thermal lens technique also allows the thermal power absorbed to be measured. The quantum efficiency Q_f of fluorescent molecular species in solution can therefore be measured using the thermal lens technique (Jun Shen & Snook 1989*b*) as the total absorbed power (excitation and thermal power) can be quantified. This method was outlined, and results for the quantum efficiency (Q_f) of sodium fluorescein in ethanol and 0.1 M NaOH were presented ($Q_\mathrm{f} = 0.92-0.97$).

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Enantiometric purity determination to 1% level using a laser-based polarimetric HPLC detector

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The development of laser-based polarimetric detectors for high-performance liquid chromatography (HPLC) (Yeung *et al.* 1980; Bobbitt & Yeung 1986) with noise levels in the range of 0.1–10 μ° has provided a significant advance in the quantitation of chiral molecules.

We have designed an instrument based on an 820 nm diode laser which has the advantages of low source flicker noise and compact design (Lloyd *et al.* 1989). Detection limits were found to be in the range 0.1–2 μg, dependent on the specific rotation of the chiral molecule and the chromatographic peak width (Goodall *et al.* 1990).

Enantiomeric purities of resolved enantiomers and enantiomer mixtures have been determined using reversed-phase achiral chromatography with polarimetric and

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Table 1. *Enantiomer mole fraction of (+)-enantiomer in blind trials*

compound	sample	achiral loading/μg	x_u[a] actual	$\bar{x}_u \pm t_{95}\, s_{x_u}/\sqrt{n}\ (n)$ chiral separation	achiral chromatography
ephedrine	standard	—	—	0.9989 ± 0.0010 (4)	—
hydrochloride	1	50	0.974	—	0.972 ± 0.004 (5)
	2	50	0.950	—	0.950 ± 0.003 (6)
fluazifop-P-butyl	standard	—	—	0.948 ± 0.005 (9)	
	1	~20	0.940	—	0.942 ± 0.016 (5)
	2	~20	0.931	—	0.938 ± 0.012 (5)
	3	~20	0.919	—	0.923 ± 0.008 (7)
	4	~20	0.910	—	0.901 ± 0.010 (7)
	5	~20	0.926	0.928 ± 0.004 (4)	0.916 ± 0.010 (8)
	6	~20	0.902	0.904 ± 0.008 (6)	0.902 ± 0.012 (8)
	7	~20	0.886	0.884 ± 0.007 (7)	0.880 ± 0.011 (6)

[a] Uncertainties in x_u are calculated from errors in pipetting and enantiomeric purity of the standards to be ±0.002 (ephedrine hydrochloride) and ±0.005 (fluazifop-P-butyl).

absorbance detectors in series to measure optical rotation, α, and absorbance, A. Enantiomer mole fractions in unknowns, x_u, were calculated from a standard, x_s, and α/A values using the equation

$$(\alpha/A)_u/(\alpha/A)_s = (2x_u-1)/(2x_s-1).$$

Table 1 shows results from an agrochemical, fluazifop-P-butyl (Wu *et al.* 1990*a*) and a drug, ephedrine hydrochloride (Wu *et al.* 1990*b*). The method always gave x_u within 1% of actual values. 95% confidence limits were roughly twice those from chiral chromatography and better than conventional polarimetry. Unlike conventional polarimetry, the method does not require chemically pure samples and can be orders of magnitude more economical in material. As an example, (+)-pseudoephedrine hydrochloride has been assayed in a cough linctus containing a 100-fold excess of sucrose.

It is anticipated that this technique will provide a convenient routine analytical method for the enantiomeric purity determination of chiral agrochemicals and pharmaceuticals, with the precision dependent upon the availability of well-characterized standard samples and the number of replicate measurements taken.

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Chemical state analysis of metal and oxide surface layers using Auger parameters from X-ray photoelectron spectroscopy

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Comparison of the relative kinetic energies of photoelectron and Auger peaks from the same element in XPS, the Auger parameter, provides unique chemical information on the top 10 nm of the surface. The Auger parameter is related directly to the extra atomic relaxation and polarization energies of the element, as presented in a chemical state plot. Previous Auger parameter studies (Wagner 1975; West & Castle 1982) have assumed a homogeneous concentration and chemical state for each element; however, in many surface analysis applications the distributions are not perfectly uniform and conventional Auger parameter analysis is not suitable.

A new method of using the Auger parameter was outlined which can be used to characterize the chemical states of ultra thin films, where bulk Auger parameter values are inaccurate. Two interactions are involved in the relaxation energy of a thin metal film as it develops.

Firstly, non-localized extra atomic screening from ligand neighbours of the substrate can be estimated by an electrostatic model (Moretti 1990). Secondly, the charge transfer from neighbouring metal film atoms during the photoelectron process influences the Auger parameter. As metallic films develop, Auger parameter values will be dominated by the substrate contribution, but gradually the neighbouring film atoms increase their influence until they are dominant in films three or more monolayers thick. A converse model has been used for multilayered oxides on metallic alloy substrates. In this case the core hole screening by conduction band electrons decreases as the oxide overlayer develops and ligand polarization begins to dominate.

The model has been applied to catalyst structures including ruthenium deposited onto alumina substrates (Aas *et al.* 1990), to gain a further understanding of their electronic distribution. Secondly, inhomogeneous oxide layers on brass surfaces, which control the alloys' optical properties, can be analysed in terms of total atom : electron ratios. In both applications where the conventional Auger parameter theory is unsuitable, new information on the surface chemistry has resulted.