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# RAMAN OPTICAL ACTIVITY

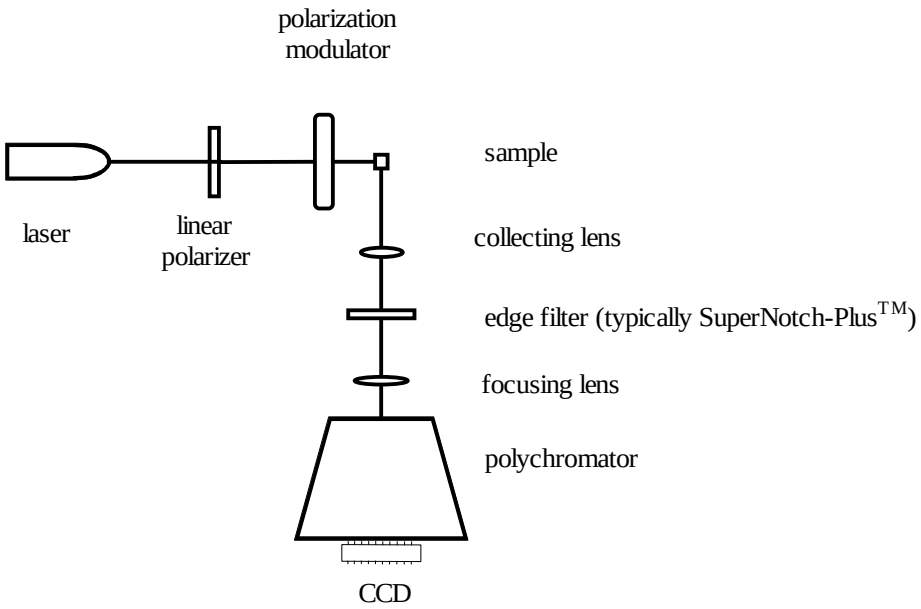
The introduction on the market of the Chiral*RAMAN*™ by *Bio*Tools Inc. is a good opportunity to review a little the technique (ROA).
Technique had a few pioneers Laurence D. Barron of the University of Glasgow, Werner Hug from Univ. of Fribourg, Laurence A. Nafie from Univ. of Oregon, to mention main players.

From the BioTools press release:

> In Raman Optical Activity one measures the difference in scattering of light for a molecule for left vs. right circularly polarized light. ROA bands for enantiomeric pairs of chiral molecules have opposite signs. ROA is a complementary technique to VCD in the same way that Raman spectroscopy is complementary to IR spectroscopy.

First papers from Barron in 1973[1] and from Hug in 1975[2] were using specialized instruments, but also Jasco, as manufacturing company of both CD and Raman equipments, was involved. In an early paper[3] they utilized available commercial components (R-800 as Raman spectrometer equipped with lock-in and J-41 PEM to circularly polarize the laser). However, due to the low sensitivity and other difficulties behind, no commercial product was later on arranged.

In the recent years the sensitivity gap has been substantially smoothed mainly using flat field polychromators with CCD detectors. This followed the similar evolution of conventional Raman spectrometers.
So while early systems using conventional monochromators and photomultiplier tube detection were based on a PEM modulated CW laser (to convert excitation from linear to modulated circular polarization) with a lock-in amplifier connected to the PM, current systems have following layout:




[1] Barron L.D., Bogaard M.P., Buckingham A.D., *J.Am.Chem.Soc.*, 95, 603 (1973)
[2] Hug W., Kint S., Bailey G.F., Scherer J.R., *J.Am.Chem.Soc.*, 97, 5589 (1975)
[3] Waki H., Higuchi S., Tanaka S., Sakayanagi N., *J.Spectrosc.Soc.Japan*, 26, 272 (1977)

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With CCD detectors, in which best sampling time is relatively long, polarization modulator should be slow, so you cannot use conventional piezoelastic modulators, you'd better use either a quarter-wave plate sequentially rotated or a Pockel cell operated by a square wave quarter-wave voltage. CCD detection should be properly synchronized with either type of modulation system.

The shown layout is the simplest form of ROA instrument, in which you apply incident circular polarization (ICP, equivalent in normal CD to FDCD). Other variants have been applied to measure SCP (scattered circular polarization, equivalent in normal CD to CPL) and DCP (dual circular polarization in which excitation is circularly polarized and you measure circular polarization of the scattering)[4].

As said above the first problem of a ROA unit is sensitivity: expected signals are three-five order of magnitudes weaker than normal Raman bands, and Raman effect gives typically weak signals anyway …..
Artifacts may be present too: main source is the residual linear birefringence of the optical train; in conventional Raman spectroscopy high solid angle collecting optics are typically used to increase efficiency, but this approach may not be the proper in ROA. A very accurate design of the sampling optics is consequently a real must.

In terms of sampling geometry both 90° and backscattering approaches have been applied., backscattering offering theoretical (and often practical) sensitivity advantages.
In the detection path back-illuminated CCD are today the standard, given their superior quantum efficiency versus the front-illuminated variants more widely used in conventional Raman. ICCD (Intensified Charge Coupled Devices) detectors may be applied also using the fast modulation frequencies of conventional PEMs, but no report seems to be available so far.
Regarding spectrometer design many latest units uses transmission rather than reflection type holographic gratings, in any case a very efficient layout is a must.

ROA is probably still one step behind VCD as a form of Vibrational Optical Activity tool, in same way conventional Raman is still behind absorption IR technique, but it'll grow by sure.
The time required to get acceptable artifact-free spectra is still longer than in VCD, but if we consider the improvements achieved in the last few years, these have been outstanding.
And we should not forget that ROA has versus VCD two basic advantages:
-a very wide wavenumber range
-water as good solvent

Do you want to know more? Pls refer to the enclosed, very partial, bibliography.

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