Imaging intra-cellular polyethylene wear debris with coherent anti-Stokes Raman scattering spectroscopy

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Overview

1. Introduction to Raman
2. Coherent anti-Stokes Raman scattering
3. Our CARS setup
4. Our model system
5. Results
6. Conclusion
Rayleigh Scattering

\[ \omega \rightarrow \omega \]

virtual state

ground state

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CH$_2$ Vibrations

- symmetric stretching
- asymmetric stretching
- scissoring
- rocking
- wagging
- twisting
Raman Scattering

virtual state

1 in 10,000,000 photons

vibrational state
Raman Spectrum - UHMWPE
Raman Spectrum - UHMWPE

wavenumber / cm⁻¹
Raman Spectrum – Cell

wavenumber / cm⁻¹
Raman Spectrum – Cell + UHMWPE

![Raman Spectrum Graph]

wavenumber / cm$^{-1}$

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Raman Mapping
Raman

• optical method
• no label required
• wide spectrum

• slow
• low resolution
• poor 3D information
Coherent anti-Stokes Raman Scattering

vibrational resonance probed

\( \omega_{\text{pump}} \)

\( \omega_{\text{stokes}} \)

\( \omega_{\text{CARS}} \)

virtual state

vibrational state

\( v=5 \)

\( v=4 \)

\( v=3 \)

\( v=2 \)

\( v=1 \)

\( v=0 \)
White Light – Refractive Index
CARS – Chemical Bonds
CARS – 3D Sectioning
CARS – Living Cells
Coherent anti-Stokes Raman

- optical method
- no label required
- narrow spectrum
- fast
- high resolution
- good 3D information
CARS – Microscope Setup

DM 570 nm

PMT

multi-mode fiber

tube lens

mirror

filters

condenser

sample

60x oil immersion lens

beam from scan unit
Macrophage Cells
Micronised Polyethylene
Wear Simulator Debris
Enhancing Contrast
Enhancing Contrast

PMMA
Polystyrene
Polyethylene

2950 cm\(^{-1}\)
3060 cm\(^{-1}\)
2850 cm\(^{-1}\)
Conclusions

• label free imaging of polyethylene and more
• fast image acquisition on live cells
• good spatial resolution
• improve chemical identity
• work on tissues
Thanks

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