

# Infrared Analysis of Carbon-Rich Polymers Using Cantilever Enhanced Photoacoustic Detector

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## Introduction

### Carbon materials in industry

- have long been used for...
- High chemical stability
- Electrochemical stability

### Even emerging demands

- e.g. Carbon-filled polymer electrode
- Flexible, mobile and conductive
- Can be used in displays and batteries

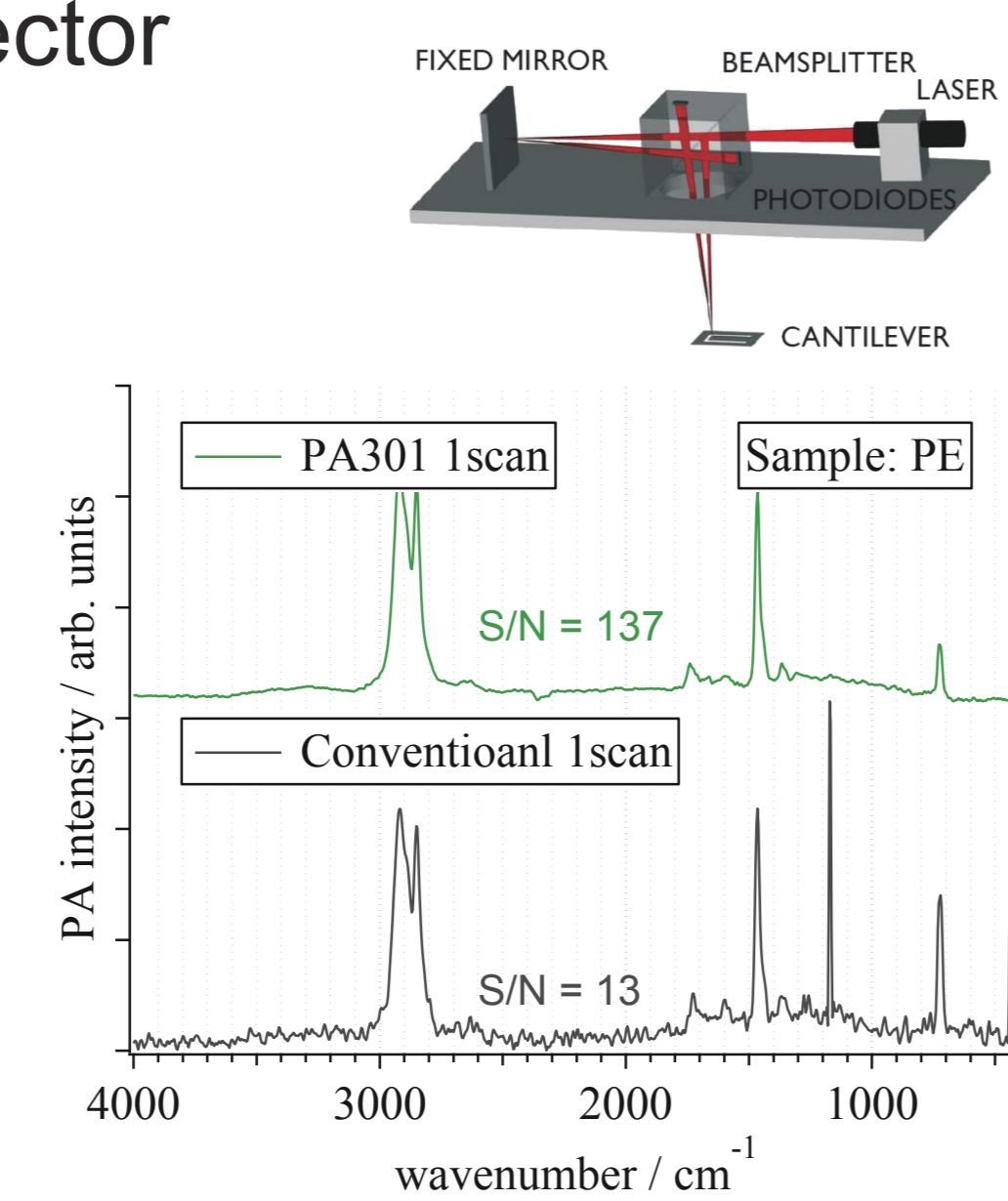
### Spectroscopy of carbon-rich materials

- Transmission: Saturated due to large absorption
- Reflection: Distorted due to high refractive index
- PAS:
  - Less influenced by absorption and refractive index
  - × Longer accumulation time due to low sensitivity of the detector

### Novel PAS detector (GASERA; booth 555)



- Cantilever and laser interferometer based detector
- Ten times more sensitive than microphone
- » 1/100 accumulation time!



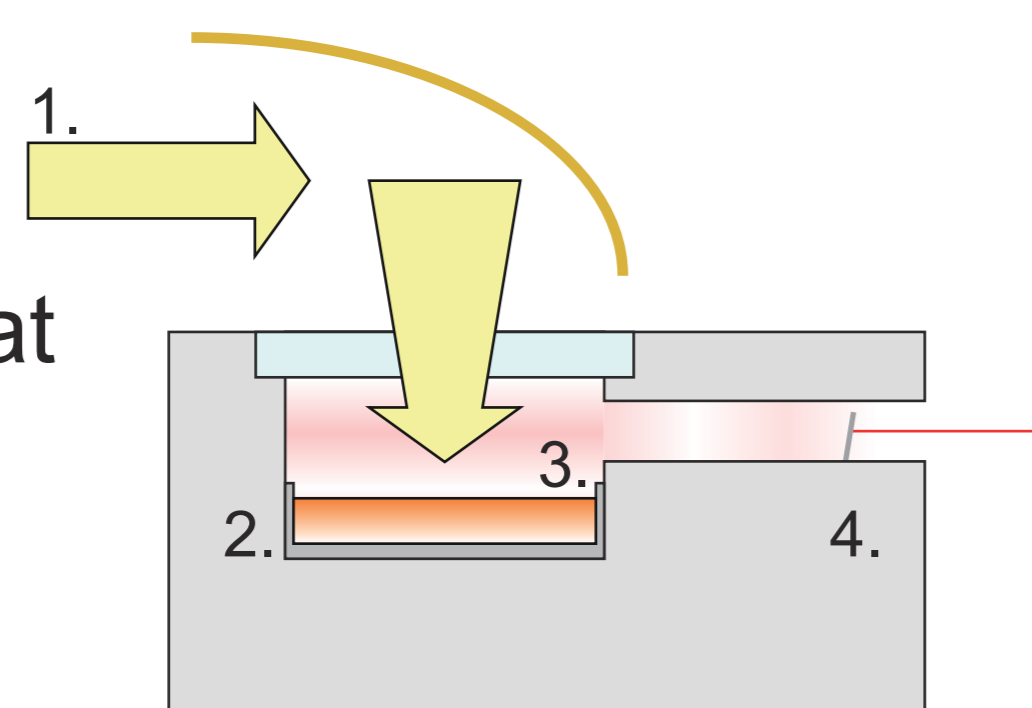
### This study

- Quantitative study on PAS spectra of carbon-containing NBR
- Investigation of the detection limit of PAS with the cantilever detector

## Photoacoustic Spectroscopy (PAS)

### Photoacoustic spectroscopy

1. Sample absorbs incident light
2. Absorbed energy partially transformed into heat (non-radiating relaxation)
3. Heat diffuses back to sample surface
4. Thermal expansion of surrounding gas detected



### PAS advantage

- Highly sensitive
- Non-destructive
- Depth-profiling
- Versatile
  - » Irregular shaped, small, or opaque sample etc.
  - » THz, IR, NIR, UV-Vis etc.

## Experiment

**FT-IR:** Bio-Rad FTS575C

**PAS detector:** GASERA PA301

### Measurement

Mirror speed: 2.5 kHz (0.1581 cm s<sup>-1</sup>); Resolution: 4 cm<sup>-1</sup>; Gain: 0.1;  
Accumulation: 32 or 256 scans

### Sample<sup>1</sup>

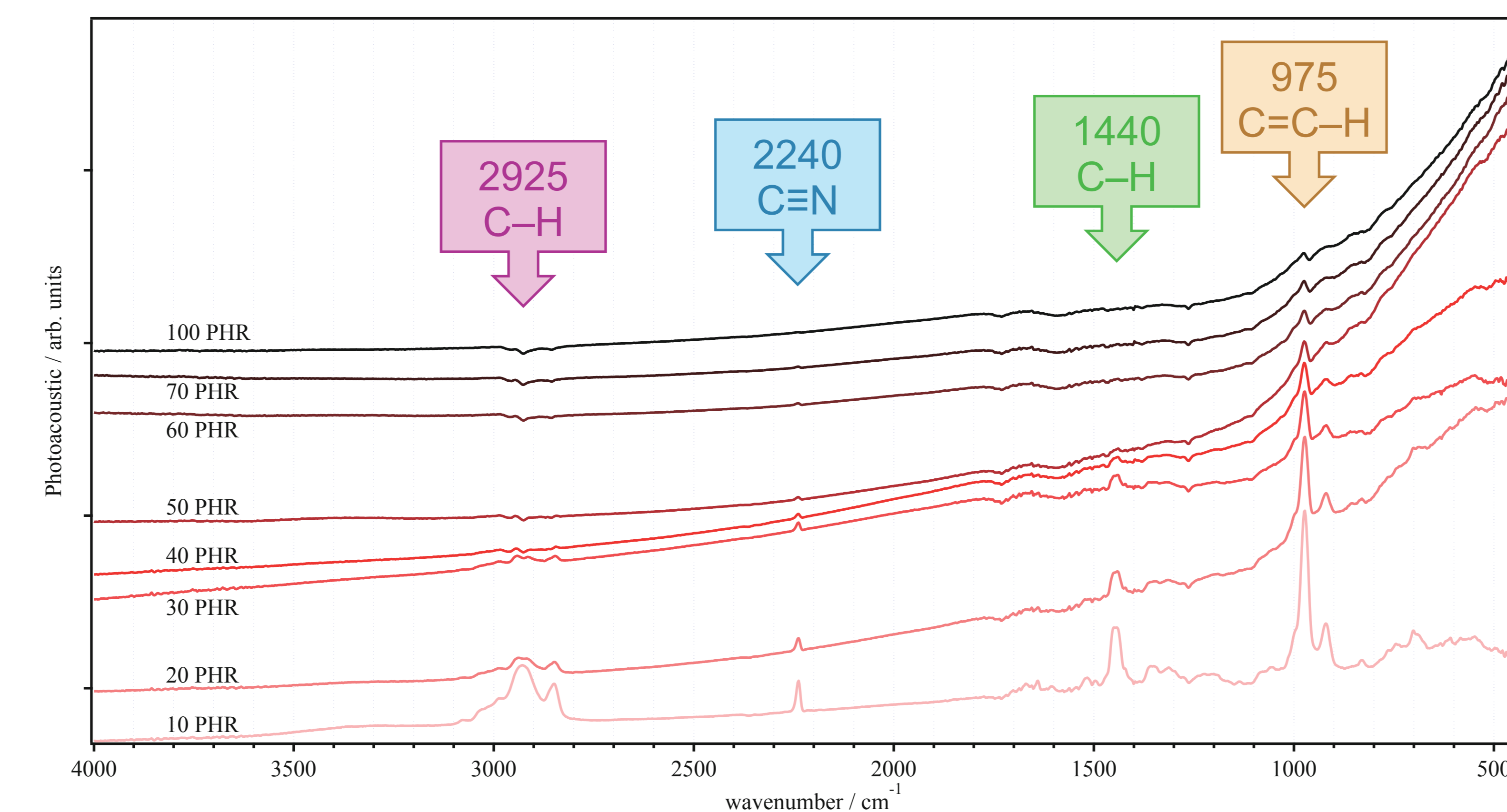
NBR Nipol® DN202 <sup>2</sup>	100	100	100	100	100	100	100	100	100
Carbon FEF	0	10	20	30	40	50	60	70	100
Antioxidant Nocrac CD	0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Antioxidant Nocrac MBZ	0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<b>Carbon %</b>	<b>0</b>	<b>8.8</b>	<b>16</b>	<b>23</b>	<b>28</b>	<b>33</b>	<b>37</b>	<b>40</b>	<b>49</b>

<sup>1</sup> These compound samples were supplied by Zeon Corporation

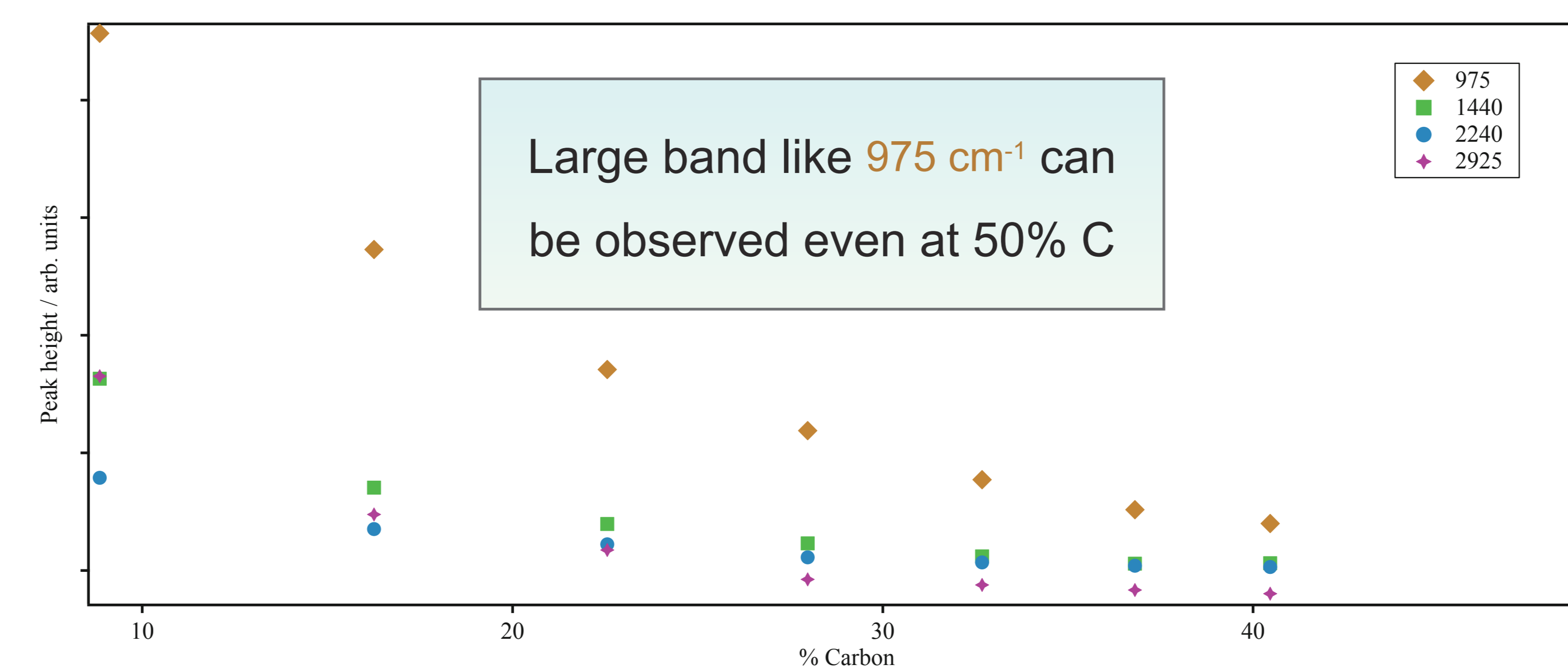
<sup>2</sup> Produced by Zeon Corporation

## Results and Discussion

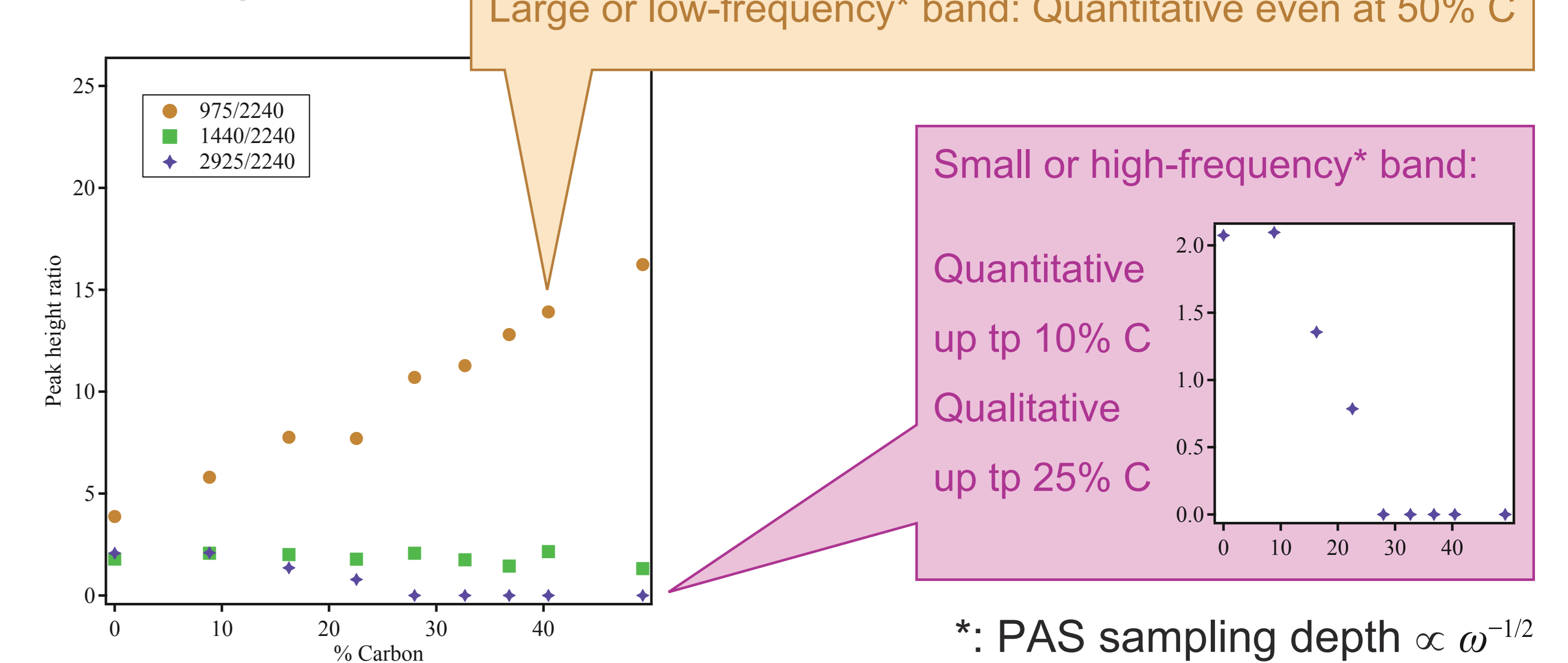
### 1. PAS spectra of carbon-containing NBR (256 scans)



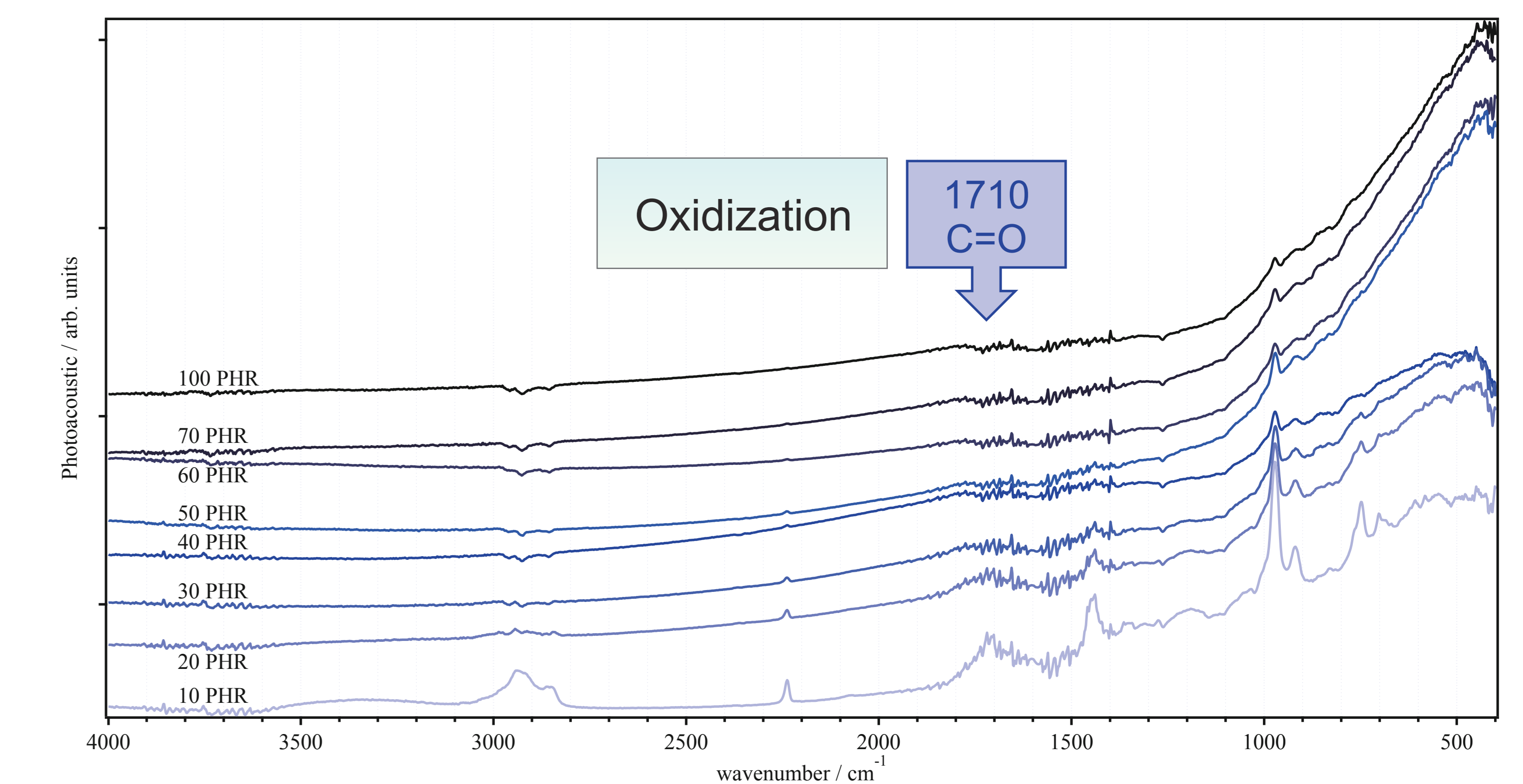
### Peak height



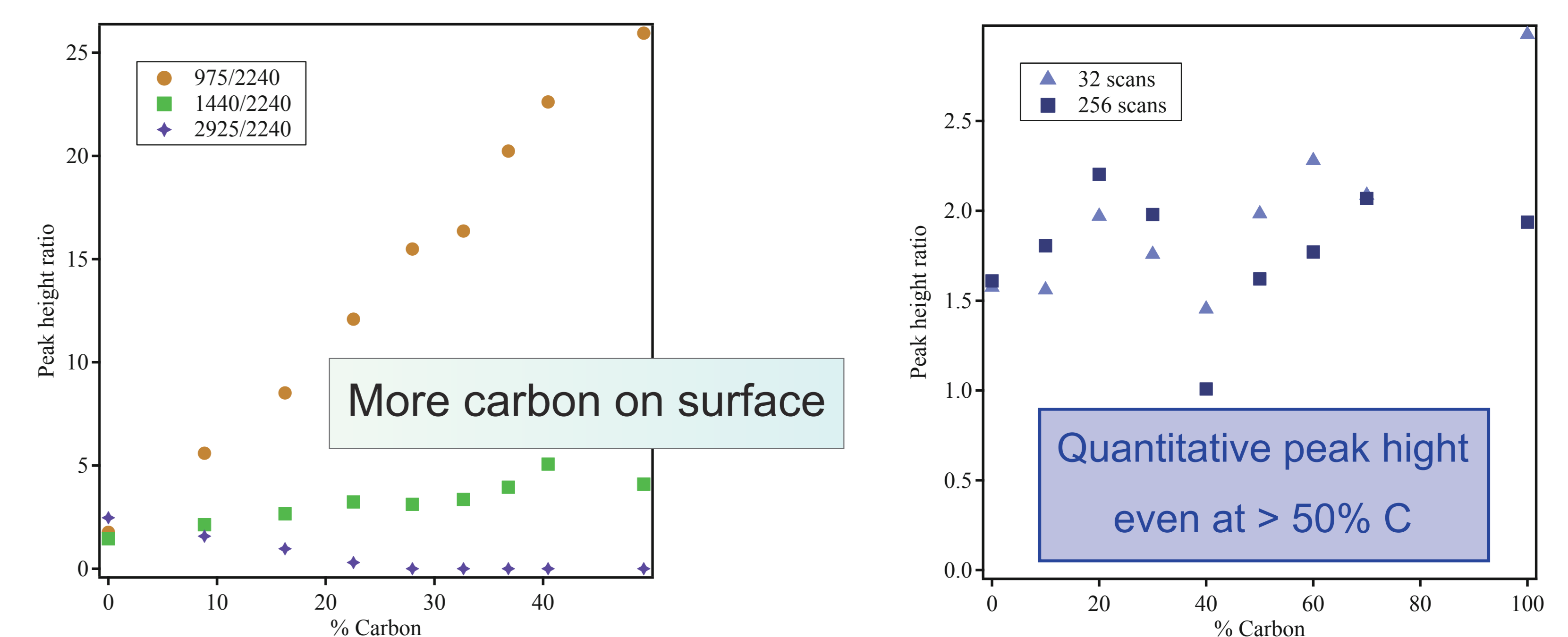
### Peak height ratio



### 2. UV irradiated (96 hr) NBR (256 scans)



### Peak height ratio



## Conclusion

PAS detection limit of carbon-rich polymer has been investigated

Small or high-frequency band: Quantitative up to 10% C

Qualitative up to 25% C

Large or low-frequency band: Quantitative up to 50% C