LU ASI Optisko biosensoru un funkcionālo nanomateriālu laboratorijas vadītāja ziņojums par darba izpildi 2023.gadā

Dr. Roman Viter
Vadošais pētnieks, Optisko biosensoru un funkcionālo nanomateriālu laboratorijas vadītājs

UNIVERSITY OF LATVIA
INSTITUTE OF ATOMIC PHYSICS AND SPECTROSCOPY

Laboratorijas kopuma informacija

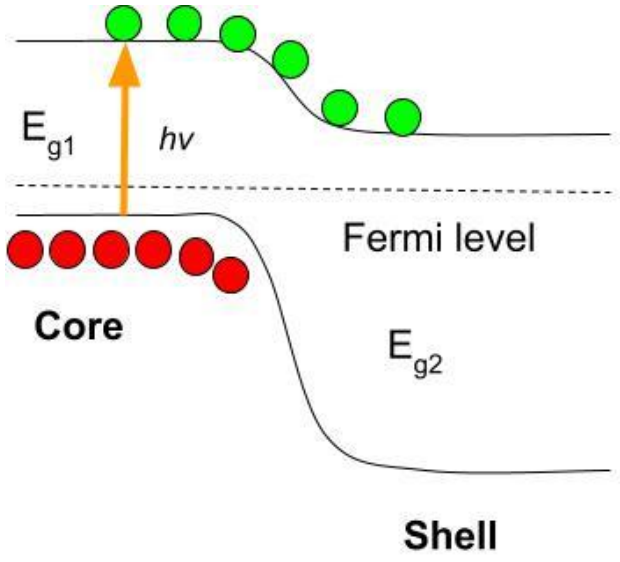
Darbnieki	**10**
• Publikacijas	**18**
• Latvijas projekti	**3**
• M-Era-Net	**3**
• Bilateral	**3**
• HE	**4**
• Konferences	**8**

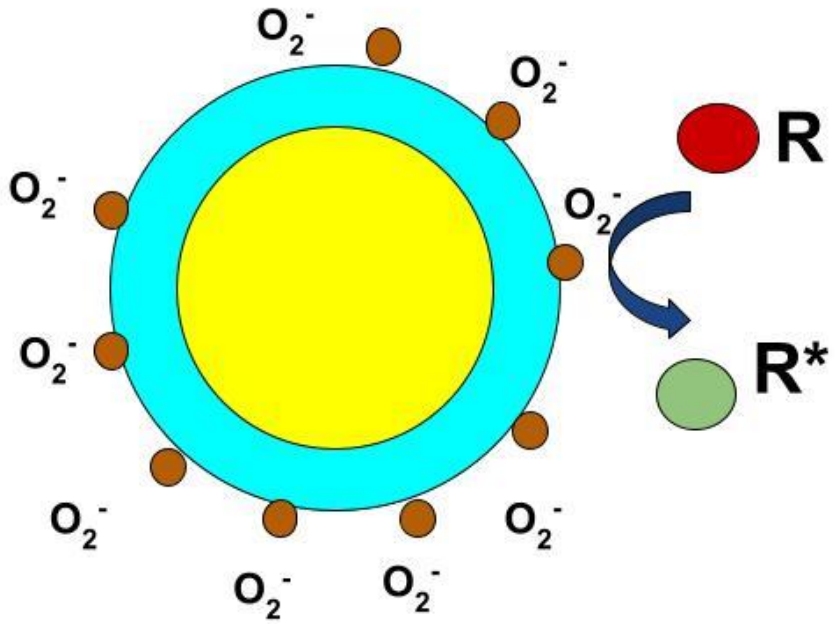
UNIVERSITY OF LATVIA

Progress in current projects

Novel core-shell nanofibers formed by co-axial electrospinning for photocatalytic applications

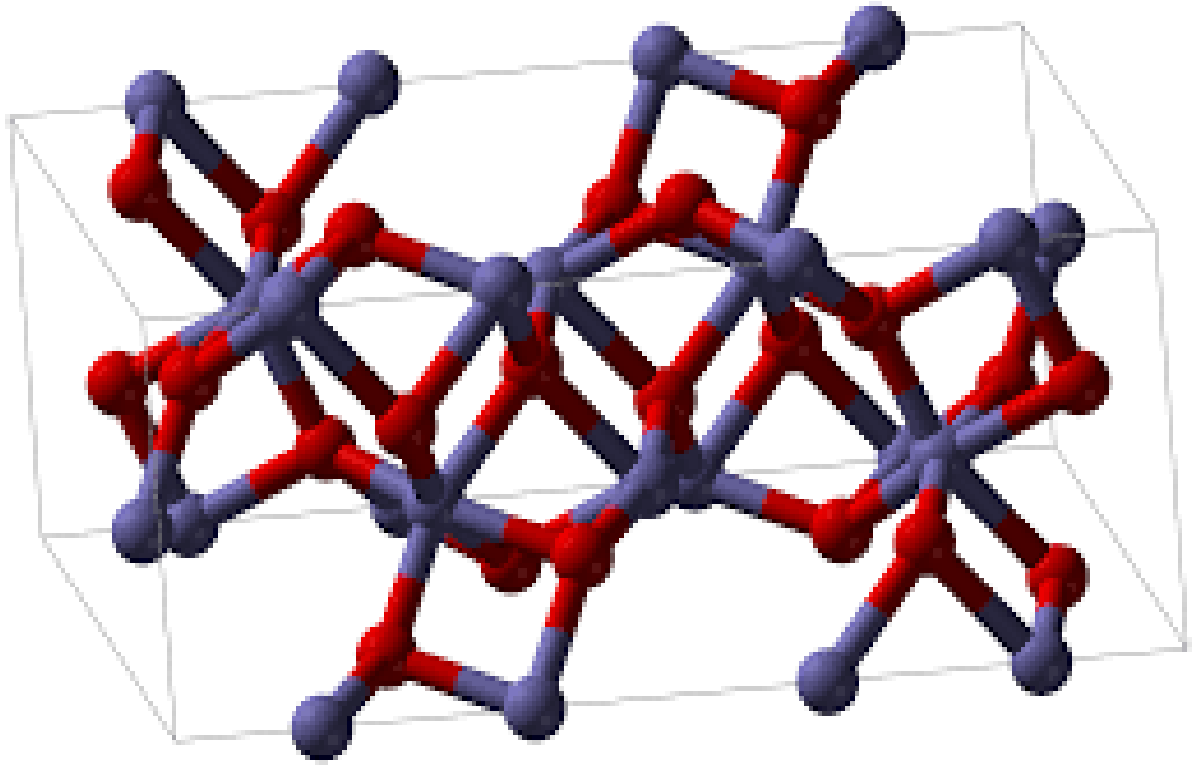
- Design and develop core-shell electrospinning fabrication of metal oxides with tunable structure and optical properties
- Increase absorption of the core-shell nanostructures in visible light
- Investigate role of fabrication parameters to structure and optical properties of core-shell nanostructures



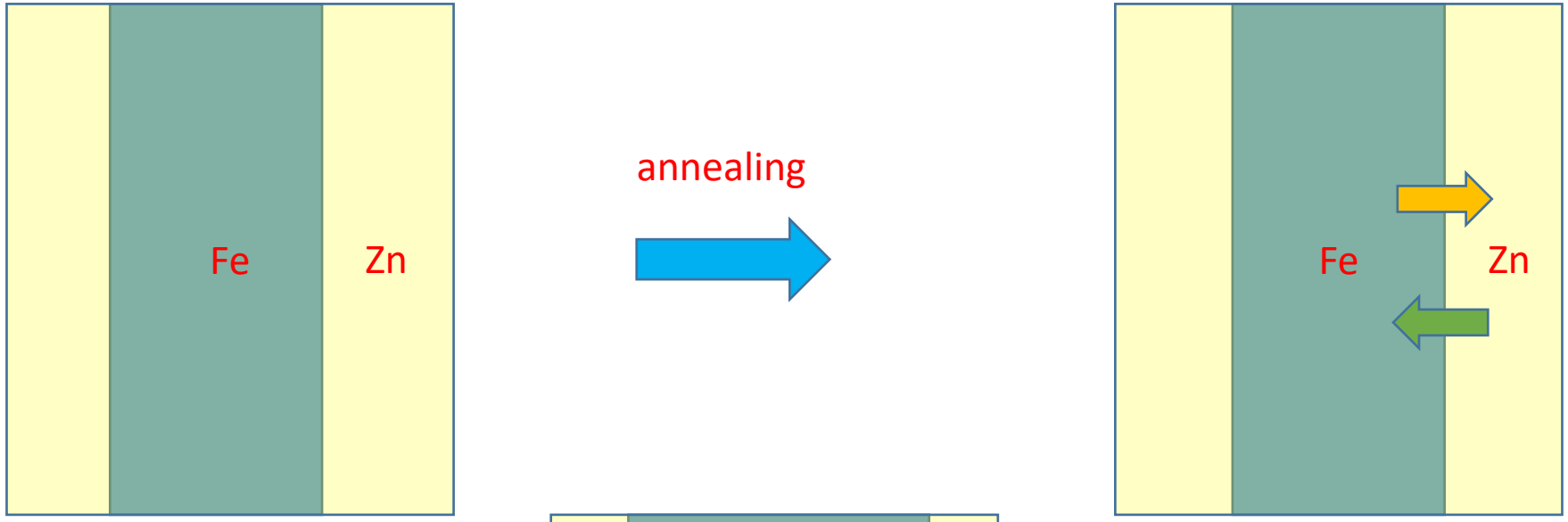


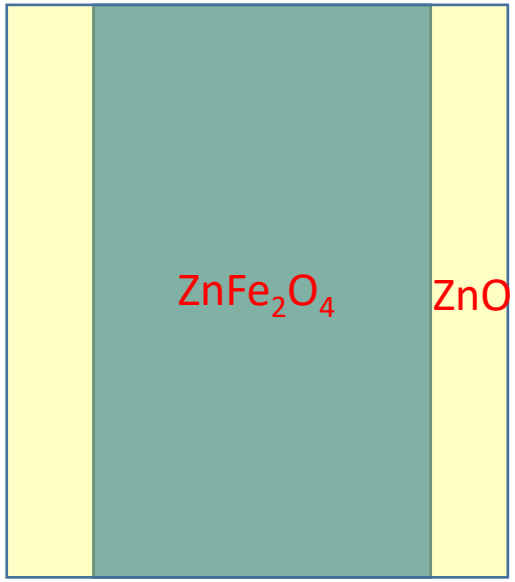
Motivation

- Development of visible light photocatalysis
- Substitution of rare materials (Pd, Pt, Au)
- Iron oxide and iron oxide derivatives
- Fe_2O_3 / Fe_3O_4 magnetic material with two band gaps (direct 2.3 eV and indirect 1.9-2.1 eV)



Current problem with magnetic materials





Spinel
Non magnetic

Current problem with magnetic materials

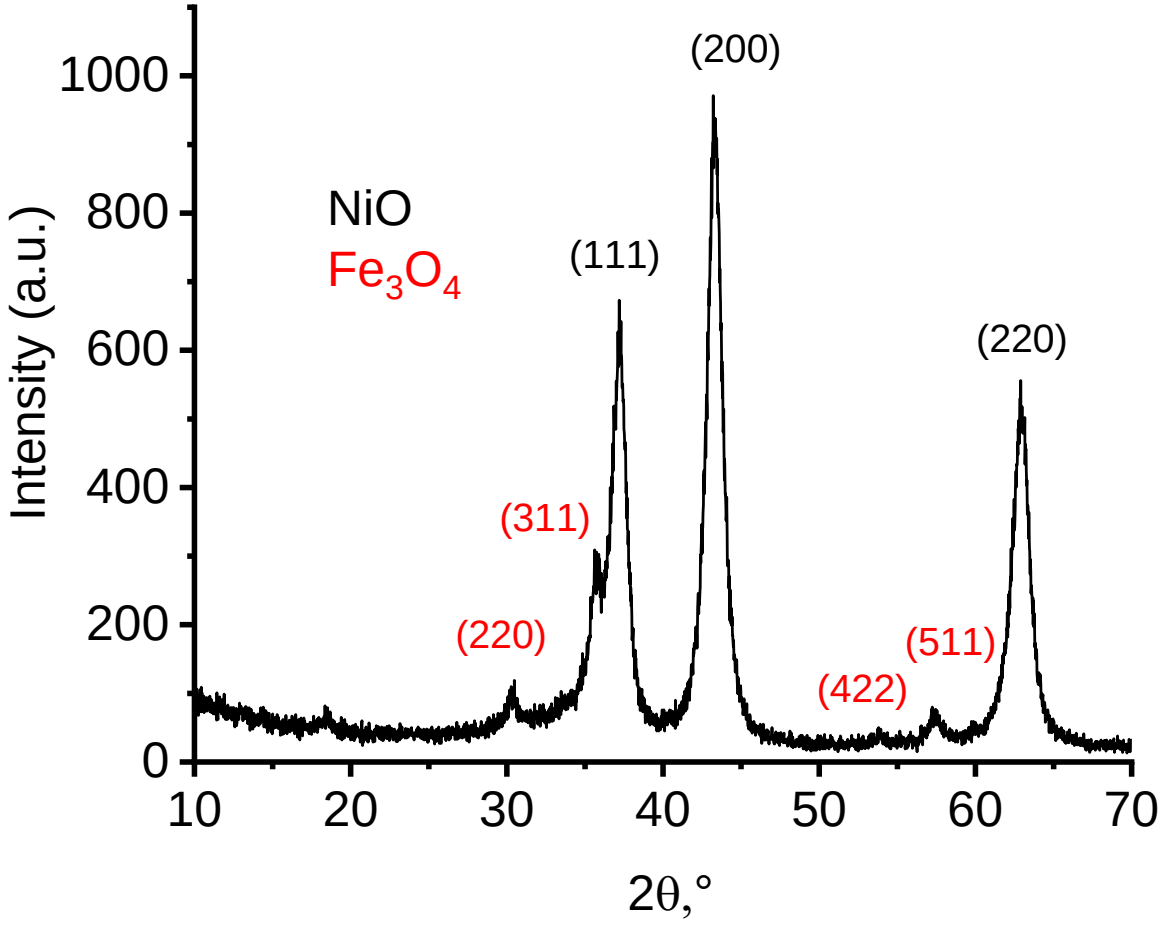
- Zn
- Ti
- W
- Mo

Non magnetic
Spinel

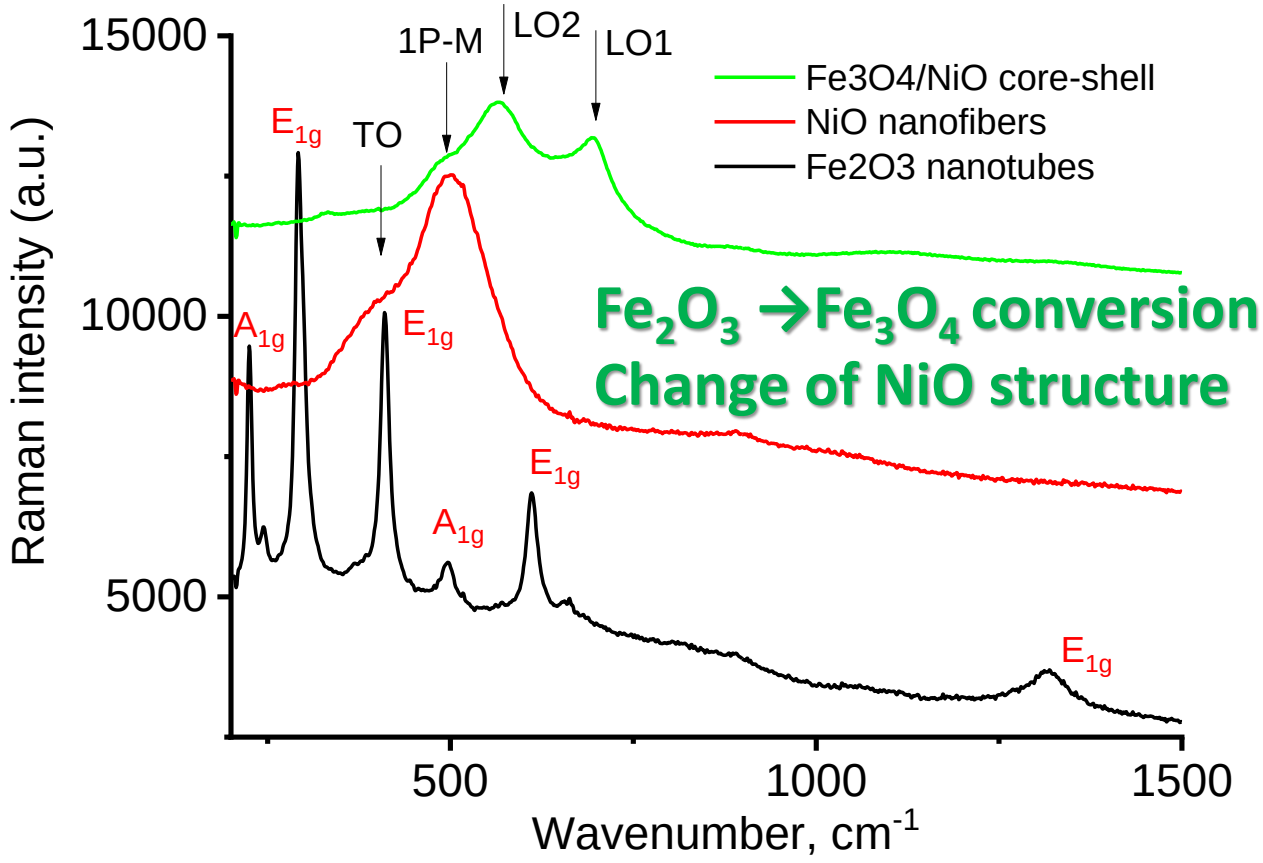
Magnetic
Spinel for Mn

- Ni
- Mn

Structural properties of FeNi oxide core-shell nanofibers

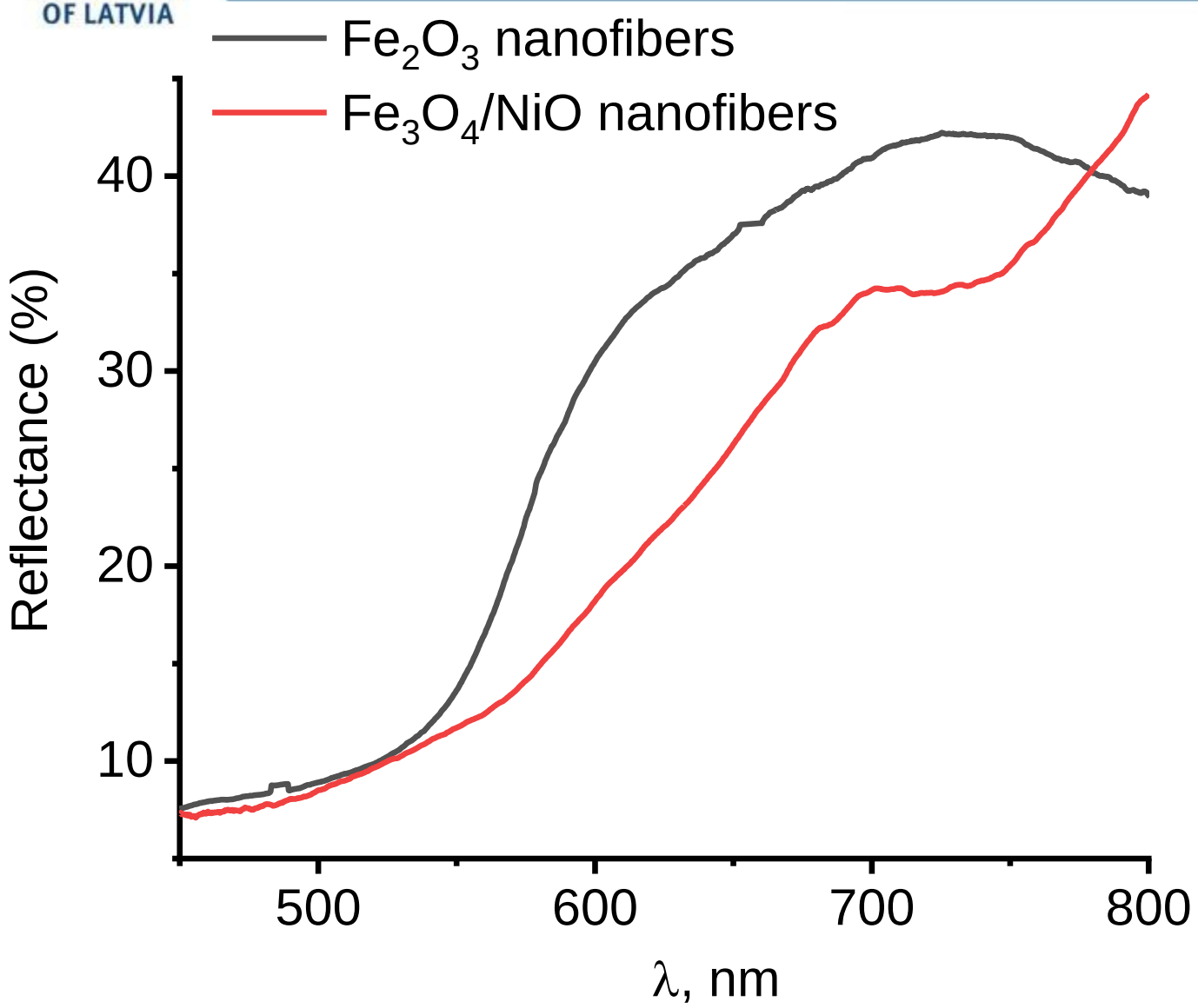


XRD spectrum of FeNi oxide core-shell nanofibers



Raman spectrum of FeNi oxide core-shell nanofibers

Optical properties

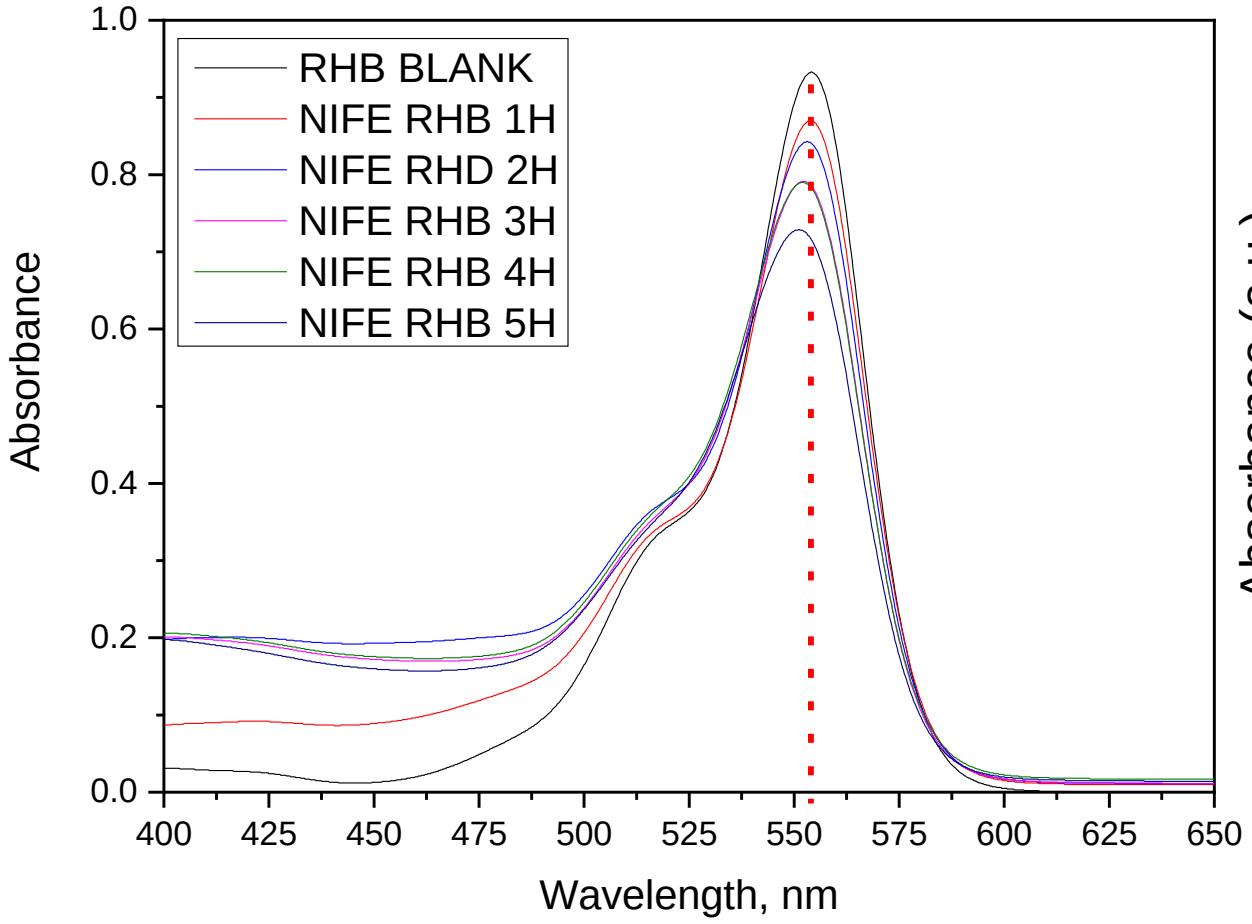


- Higher absorption in VIS-NIR range
- Two absorbance bands
- Prospective for visible light photocatalysis

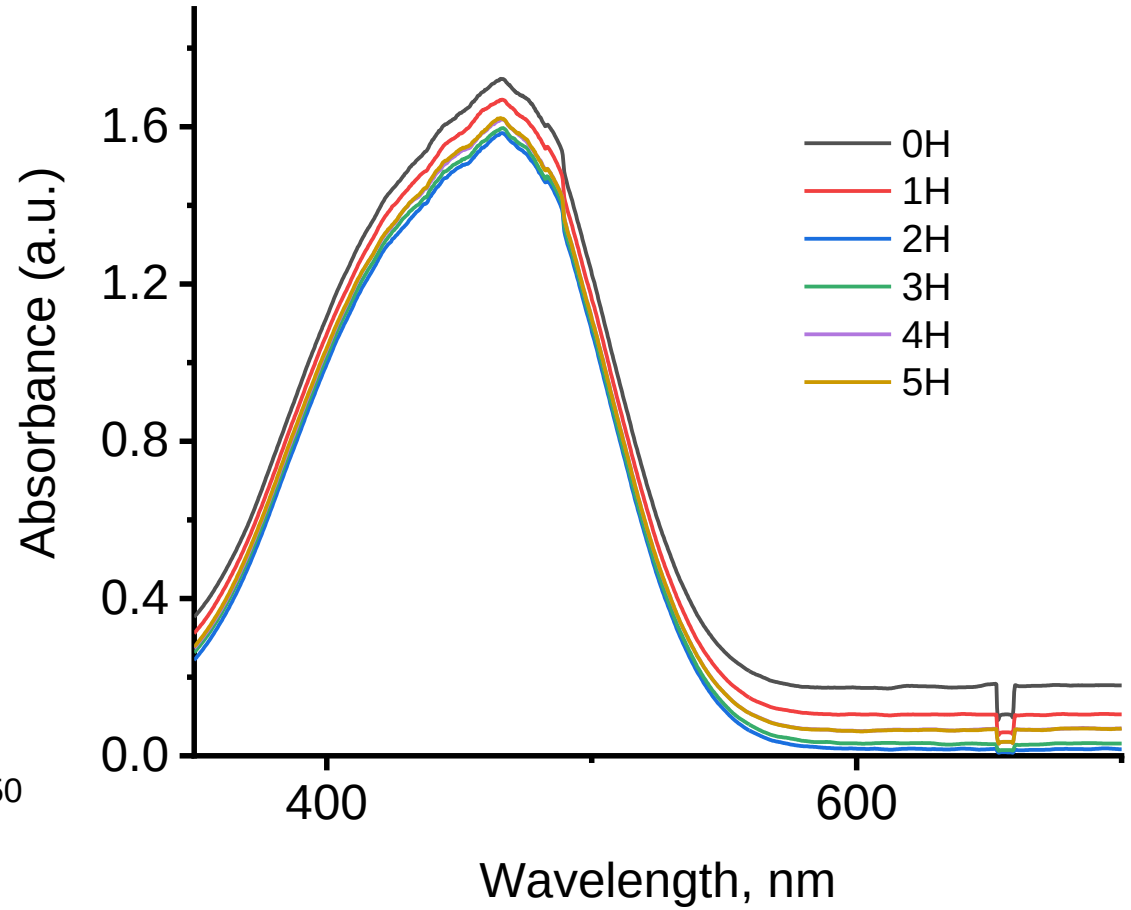
$E_g(NiO) > E_g(Fe_2O_3) > E_g(Fe_3O_4) > E_g(Fe_3O_4/NiO)$

Defects and surface states at interface

Photocatalysis properteis



Rhodamin



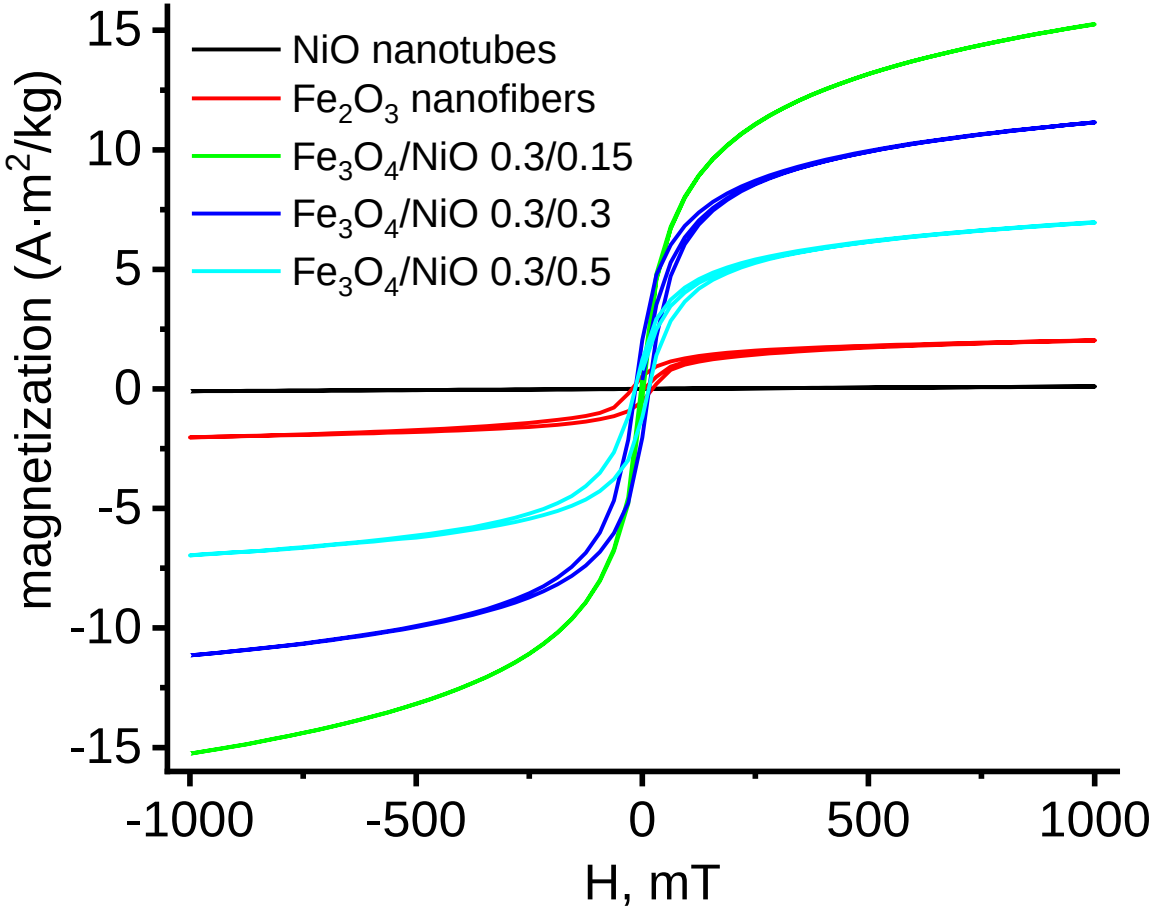
Methylorange

UNIVERSITY OF LATVIA

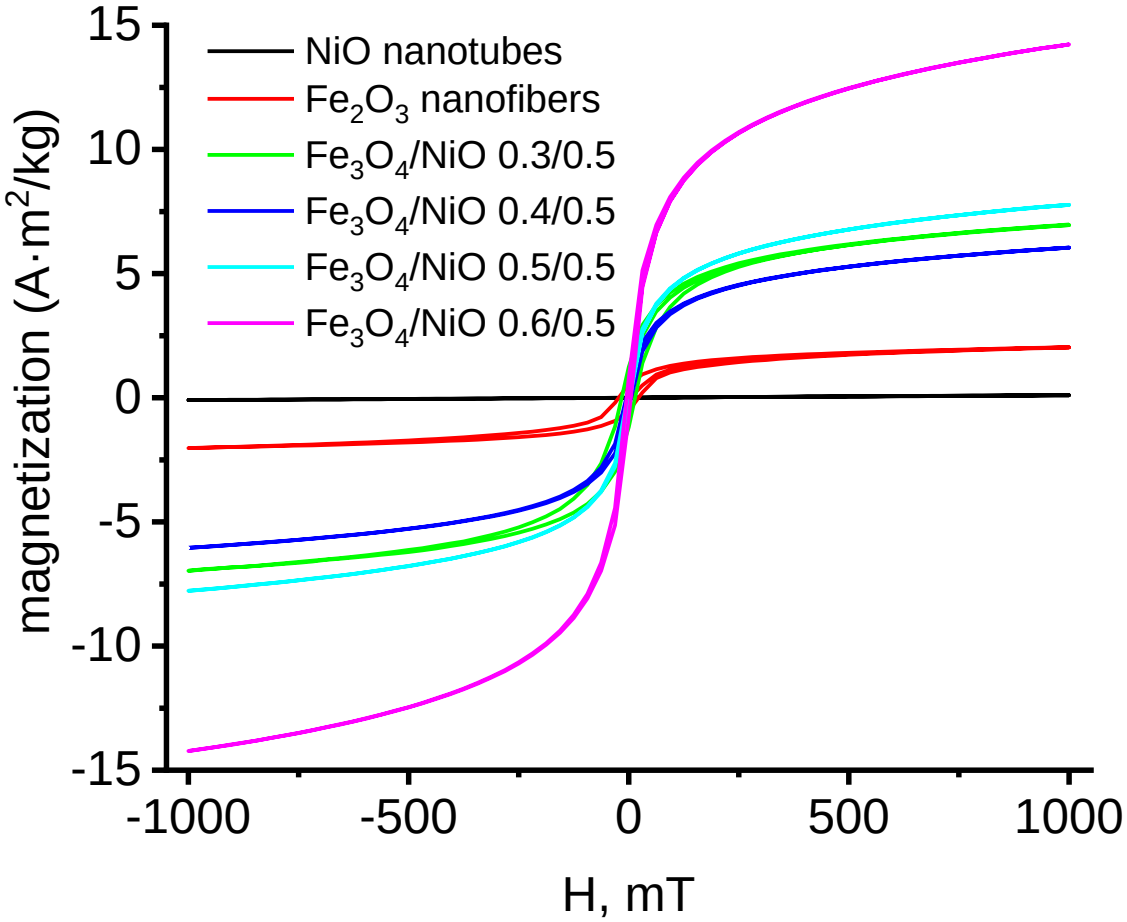
Sample optimization

- To get fixed concentration of core precursor
- To get fix concentration of shell precursor
- To increase the annealing temperature

Magnetic properties of FeNi oxide core-shell nanofibers



Fixed concentration of Fe



Fixed concentration of Ni

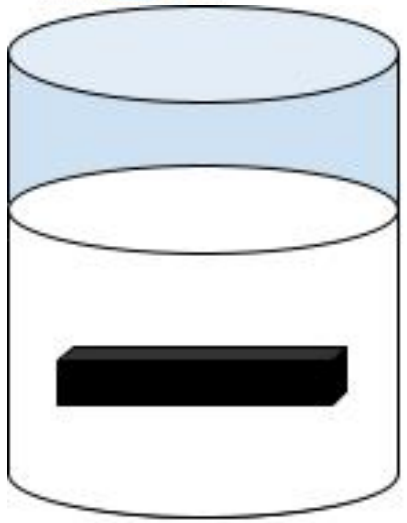
Next steps

- Optical properties
- XRD, SEM/TEM
- Z-potential
- Photocatalysis of dyes at different pH
- Optimization of FeMn structure to improve magnetic properties
- 3 papers
- 1 patent

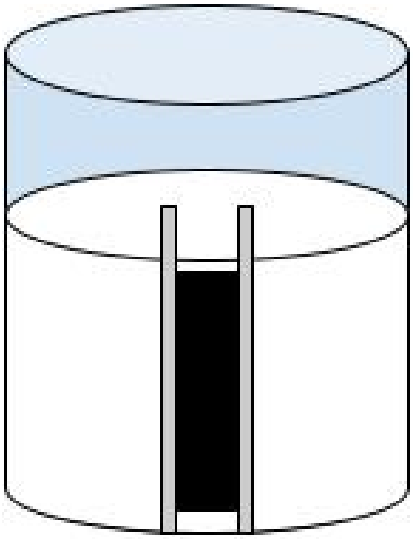
UNIVERSITY OF LATVIA

VPP project

Improvement of h-WO3 synthesis

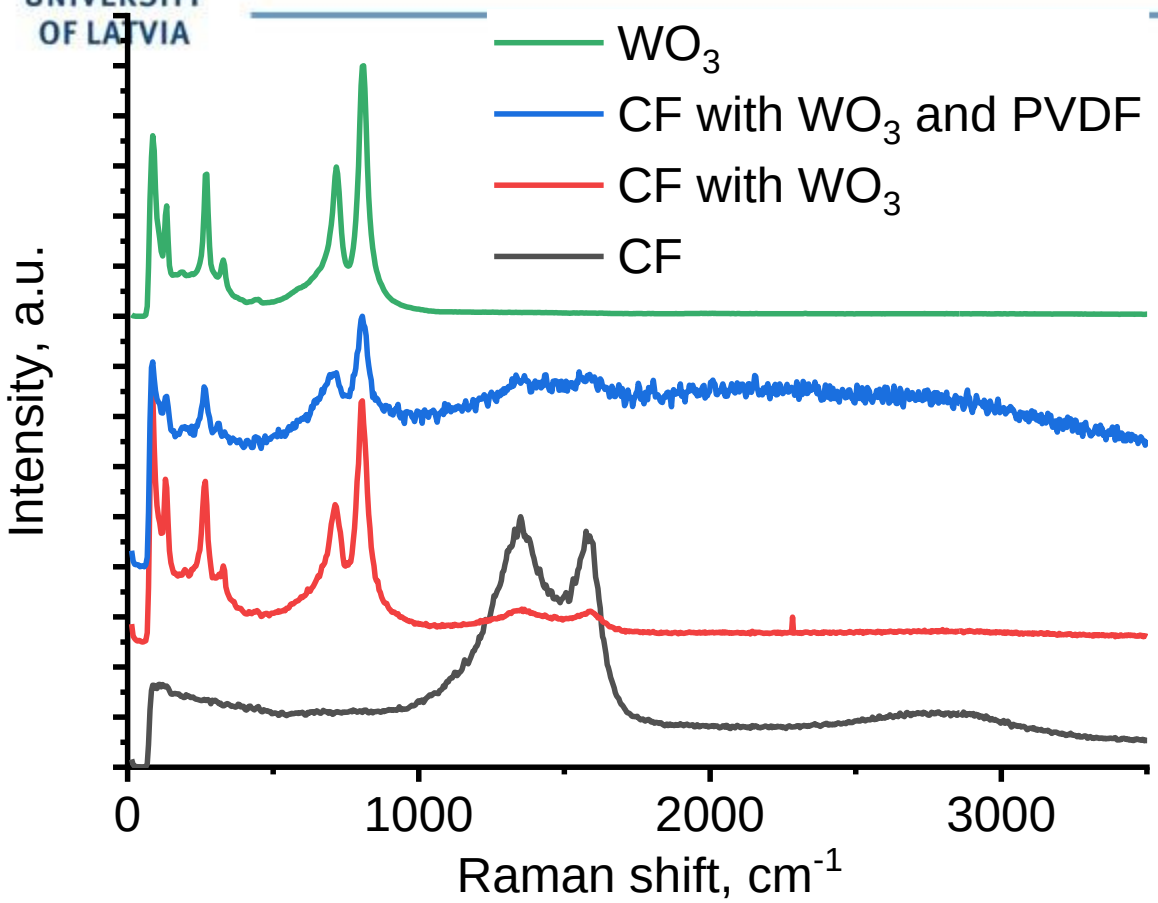


h-WO_3 particles adsorbed on CF surface
Release to solution from CF surface during electrochemical tests

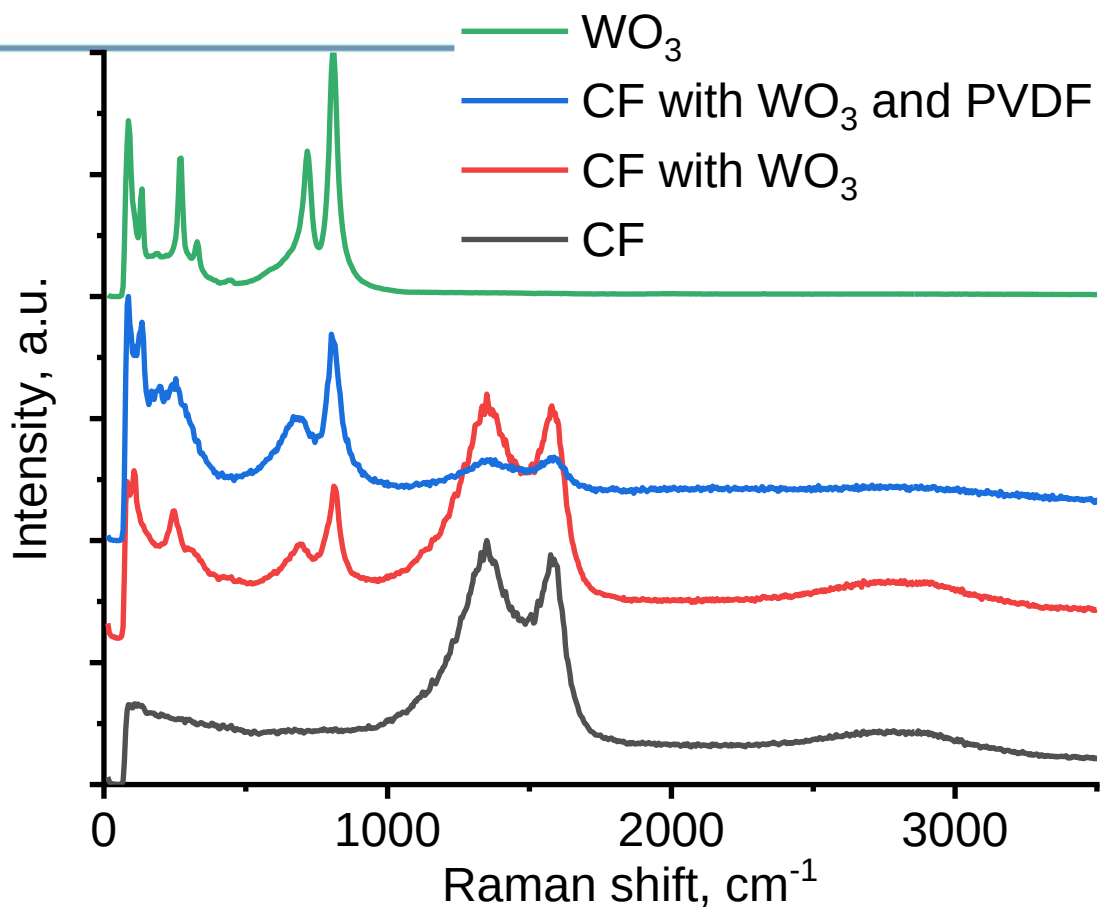


Special chemically inert quartz holder
Block precipitation of particles
Better repeatability of the h-WO_3 mass, deposited into carbon felt

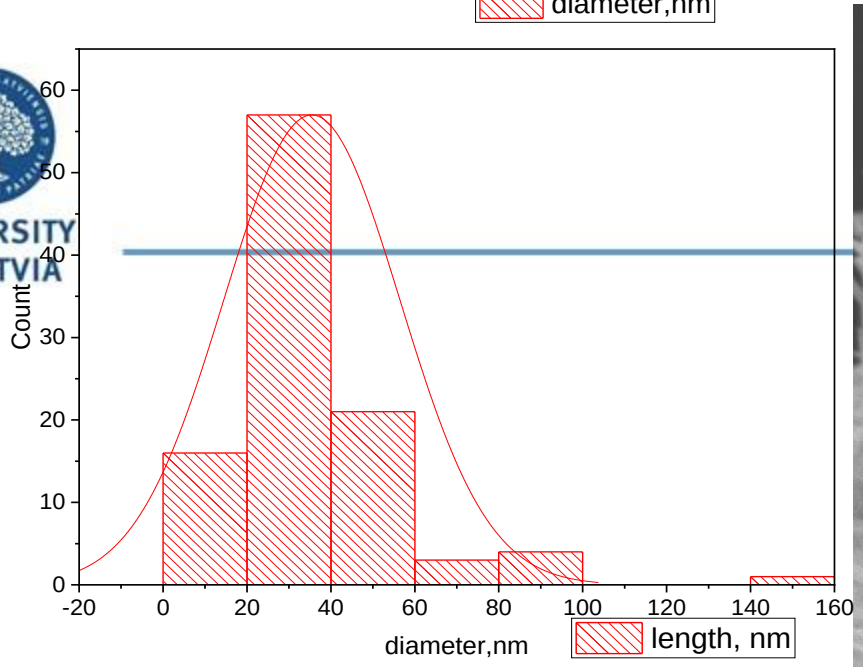
Raman spectra of WO_3

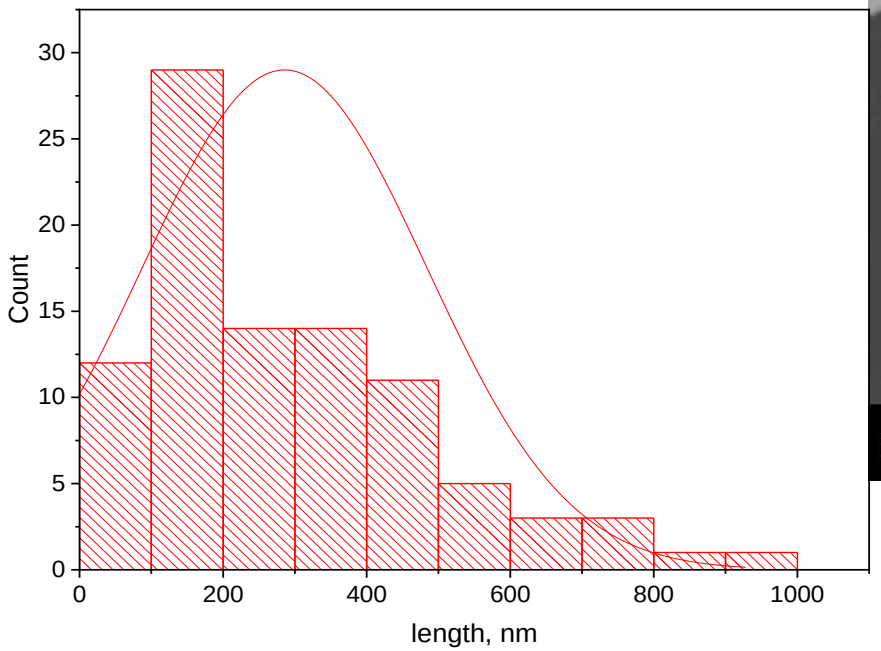


Raman spectra for CF with WO_3 and PVDF
(in the volume of CF)

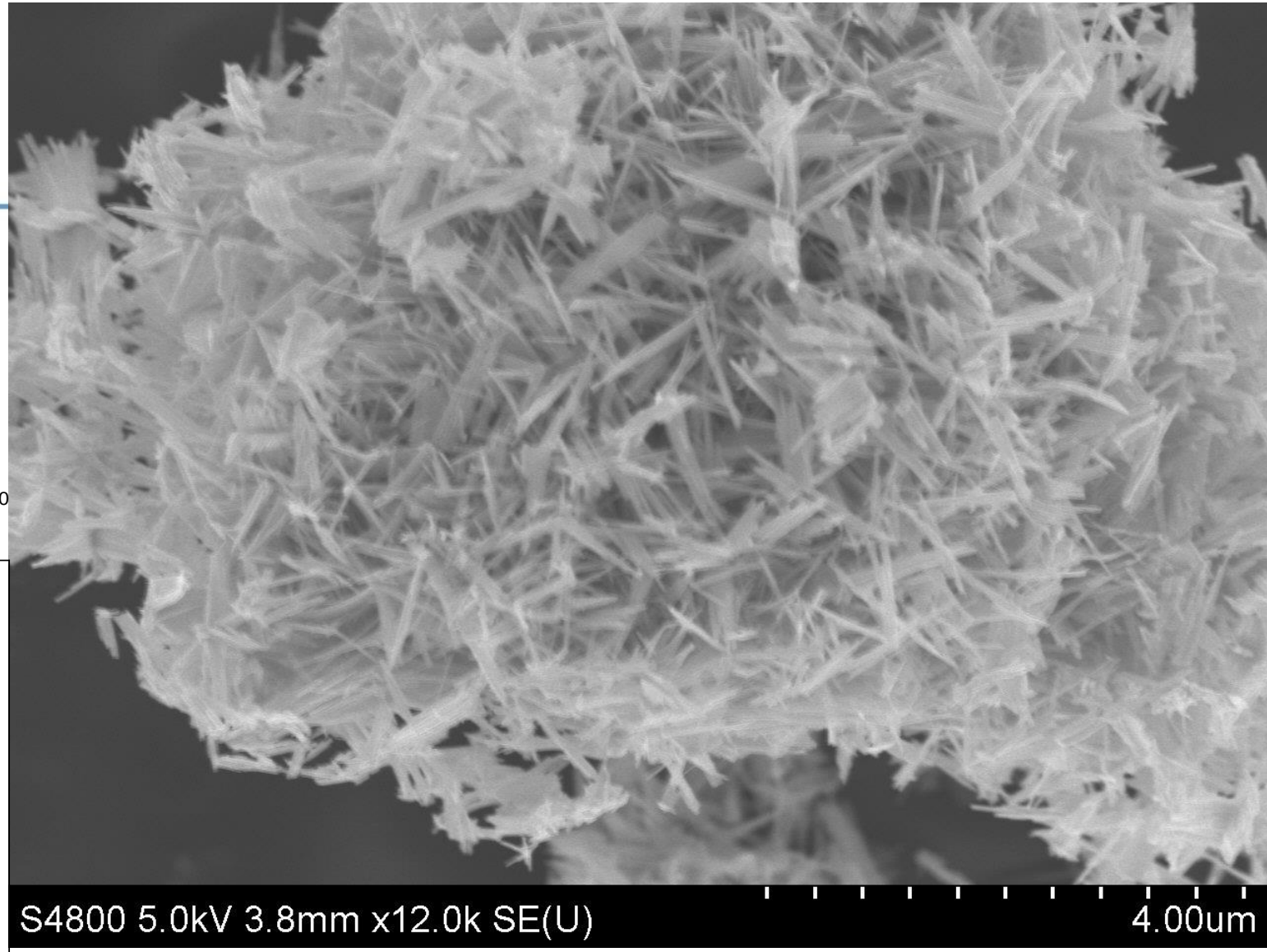


Raman spectra for CF with WO_3 and PVDF
(on the surface of CF)





Dimensions of WO_3 nanorods



SEM image of WO_3

WP5 Fabrication of h-WO3 nanostructures

- 1. Scale up of h-WO_3 powder fabrication (3.5 g/day)
- 2. Preparation of h-WO_3 powder with different molarity of tungsten soluti
- 3. Preparation of h-WO_3-Au composite nanostructures
- 4. Fabrication of h-WO_3 nanostructures doped with:

Ni [M(Ni2+)/(M(W6+)=0.05] Cr [M(Cr3+)/(M(W6+)=0.05] Co]M(Co2+)/(M(W6+)=0.05]

Structural properties (SEM, XRD, Raman are under investigation)

UNIVERSITY OF LATVIA

WP2, 4 Functional polymers

Development of smart materials

- Adding natural raw materials from wood and plants
- Improving the quality of existing products
- Nanotechnology and applied area
- Fast, low cost and portable characterization methods
- Interdisciplinary approach (physics, chemistry and biotechnology)

Changing polymer properties

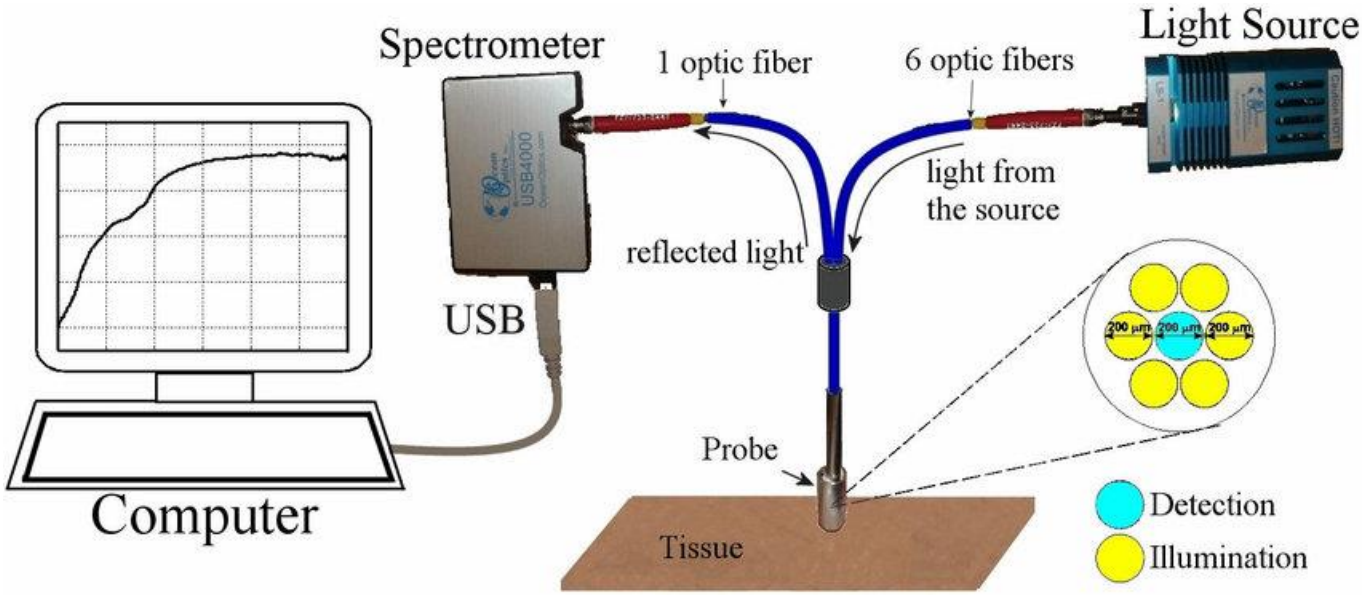
- Polybutylene

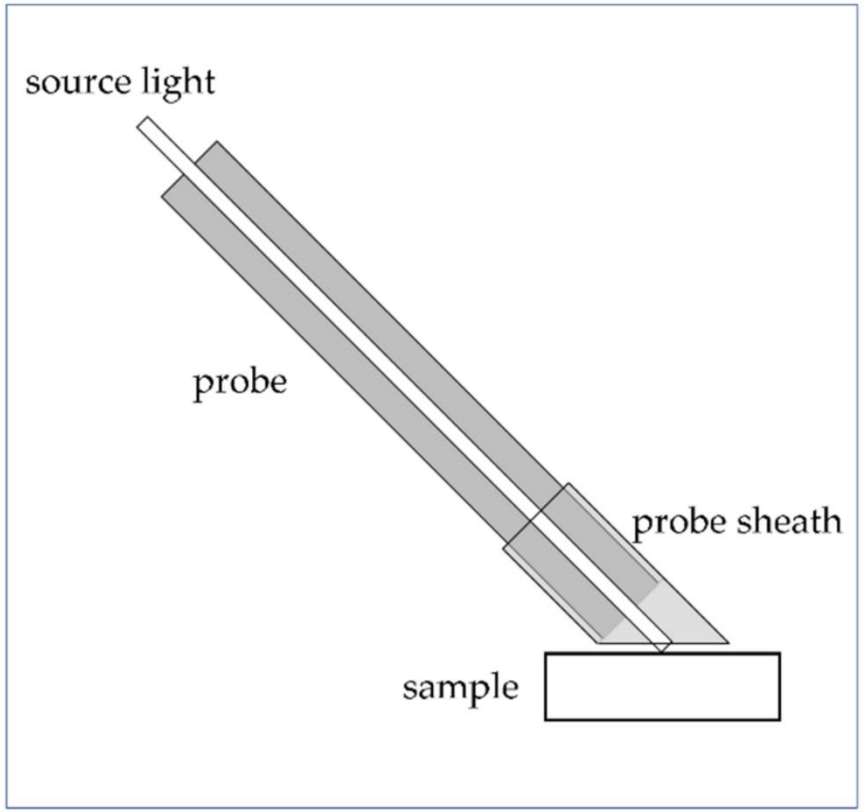
Chitosan

Fabrication of bio degradable polymers

- Powder samples were prepared:
- PBE-Chitosan 95 (Chitosan 95: 0%, 3%, 5%, 7% 10%)
- PBE-chitosan 98 (Chitosan 98: 0%, 3%, 5%, 7% 10%)
- All were granulated and then hot melt extruded
- Optical properties characterization: FTIR and photoluminescence spectroscopy
- Degradation test: incubation of 5 mg powder in 2 ml H_2O+1 microliter of NH_4OH for 1 week
- PBE-polybutylene

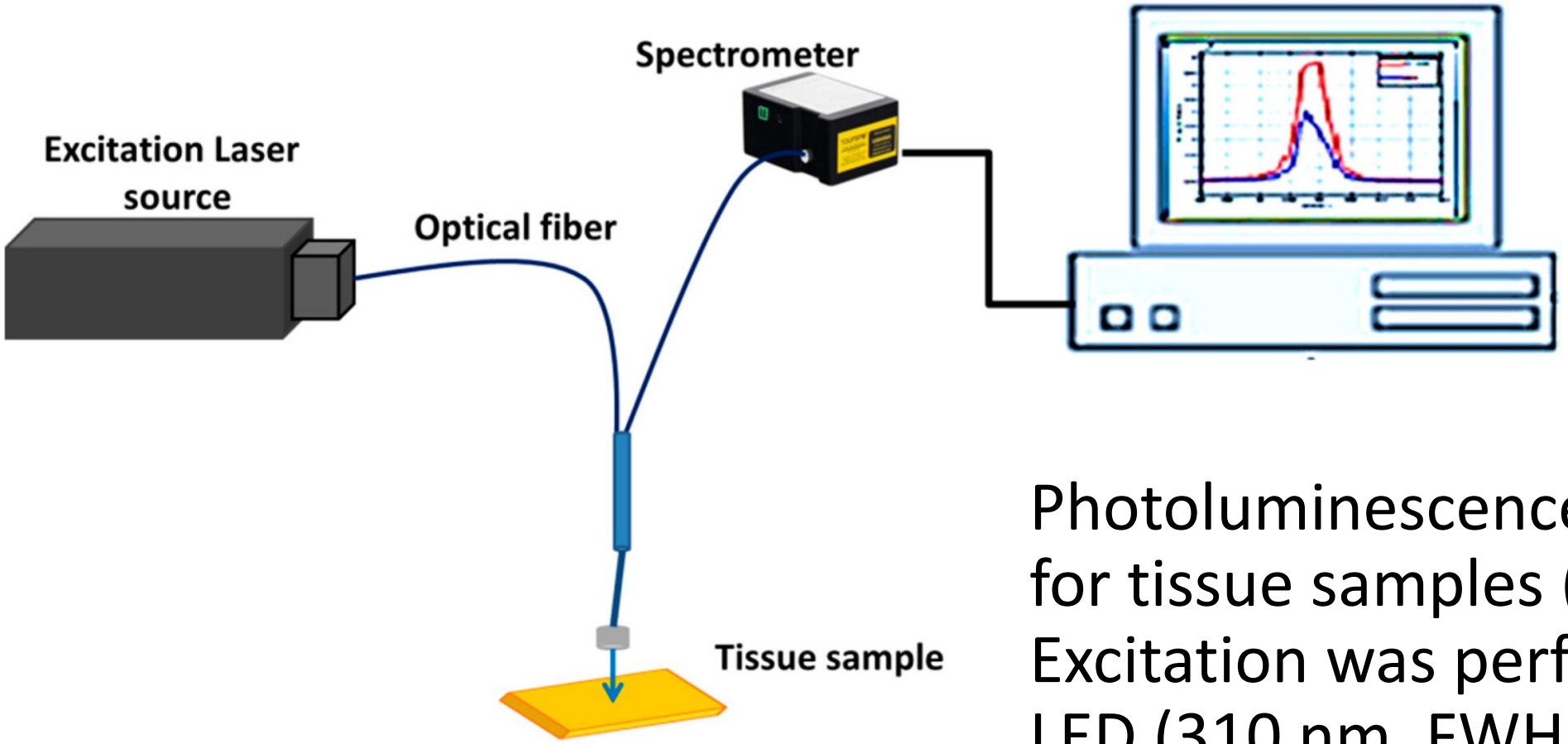
Diffuse reflectance





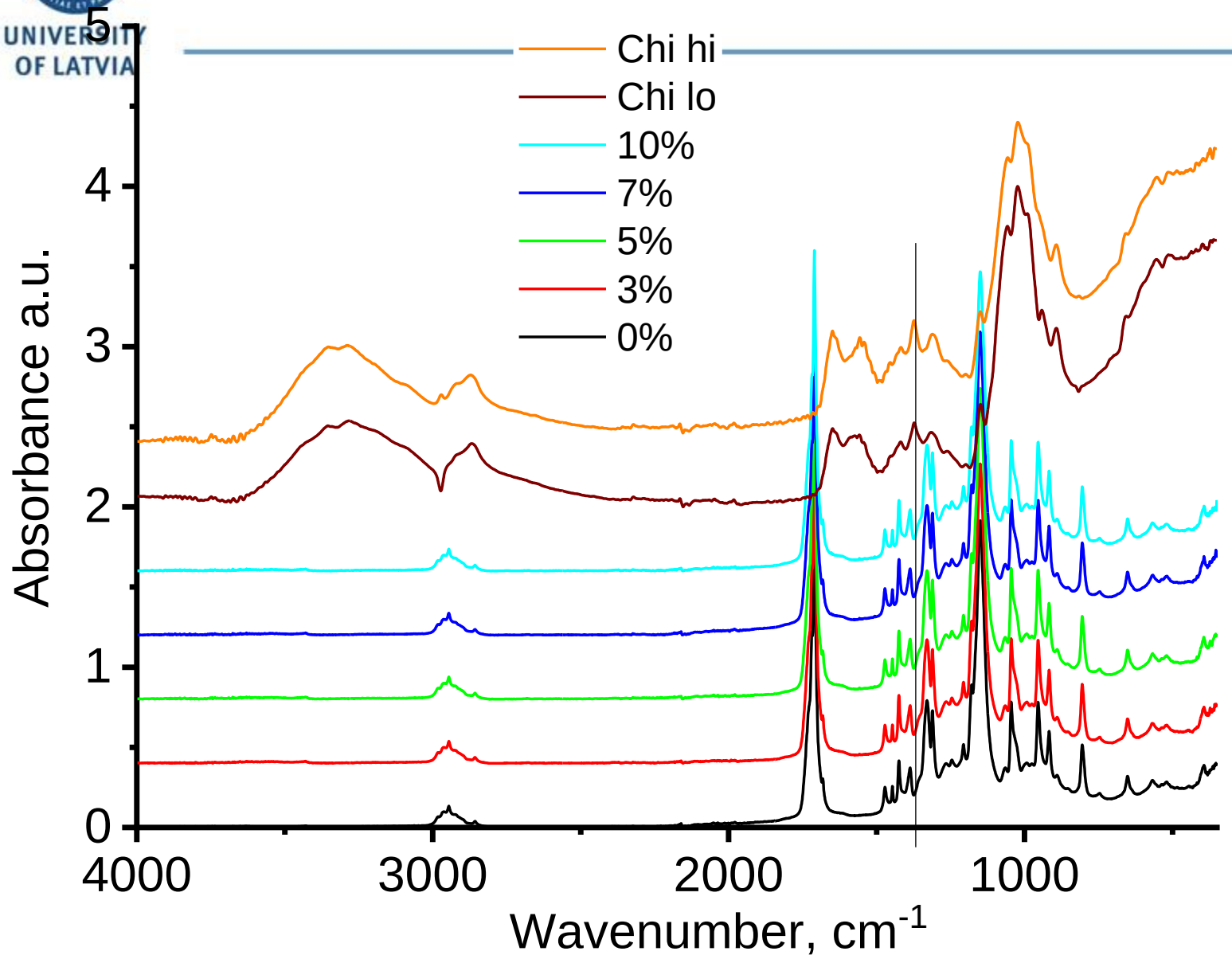
Diffuse reflectance was measured for tissue samples (250-700 nm). Probe to sample angle was 45^0.

Photoluminescence



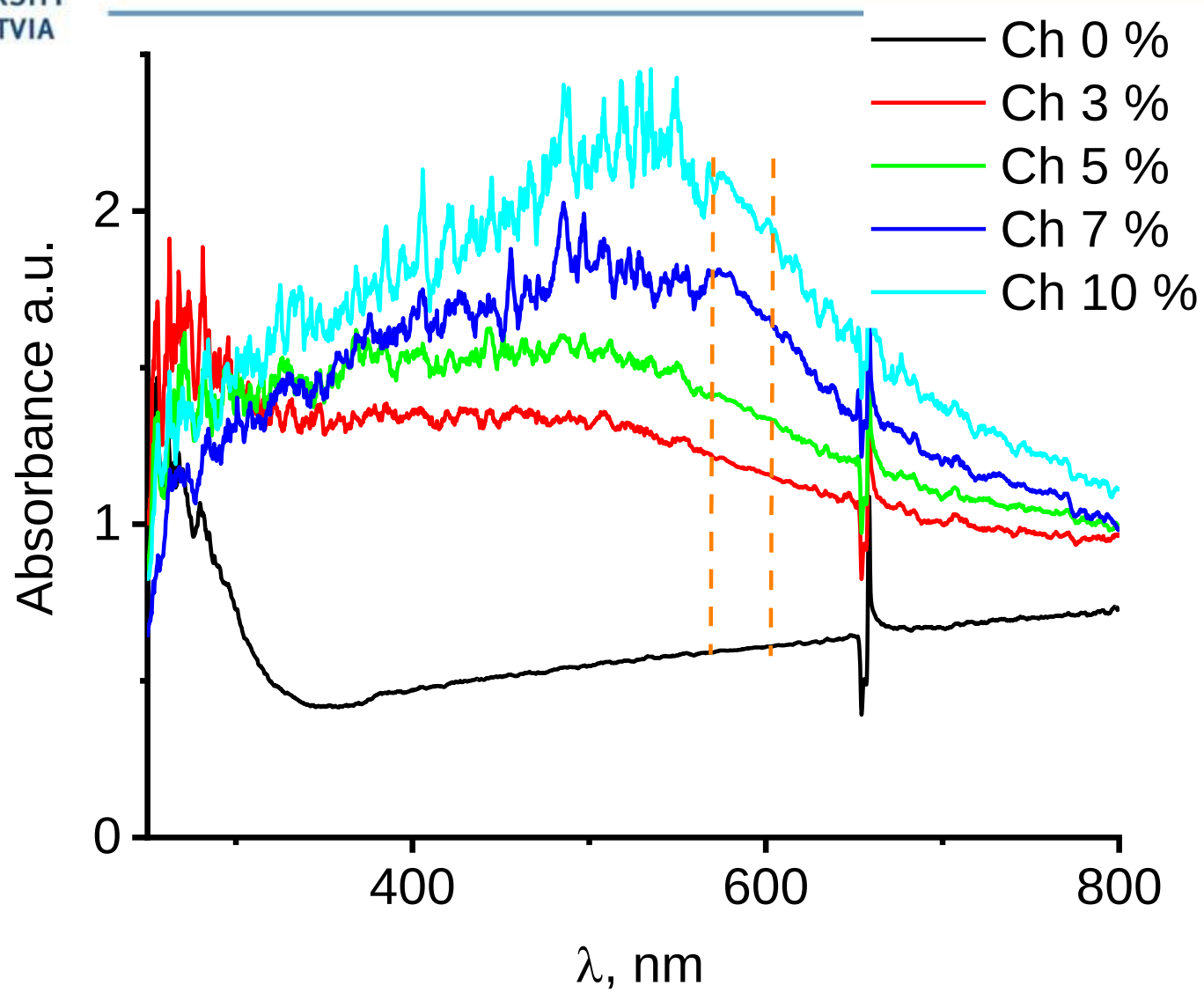
Photoluminescence was measured for tissue samples (250-700 nm). Excitation was performed by UV LED (310 nm, FWHM 10 nm, output power 3 mW)

PEE-Chitosan-FTIR



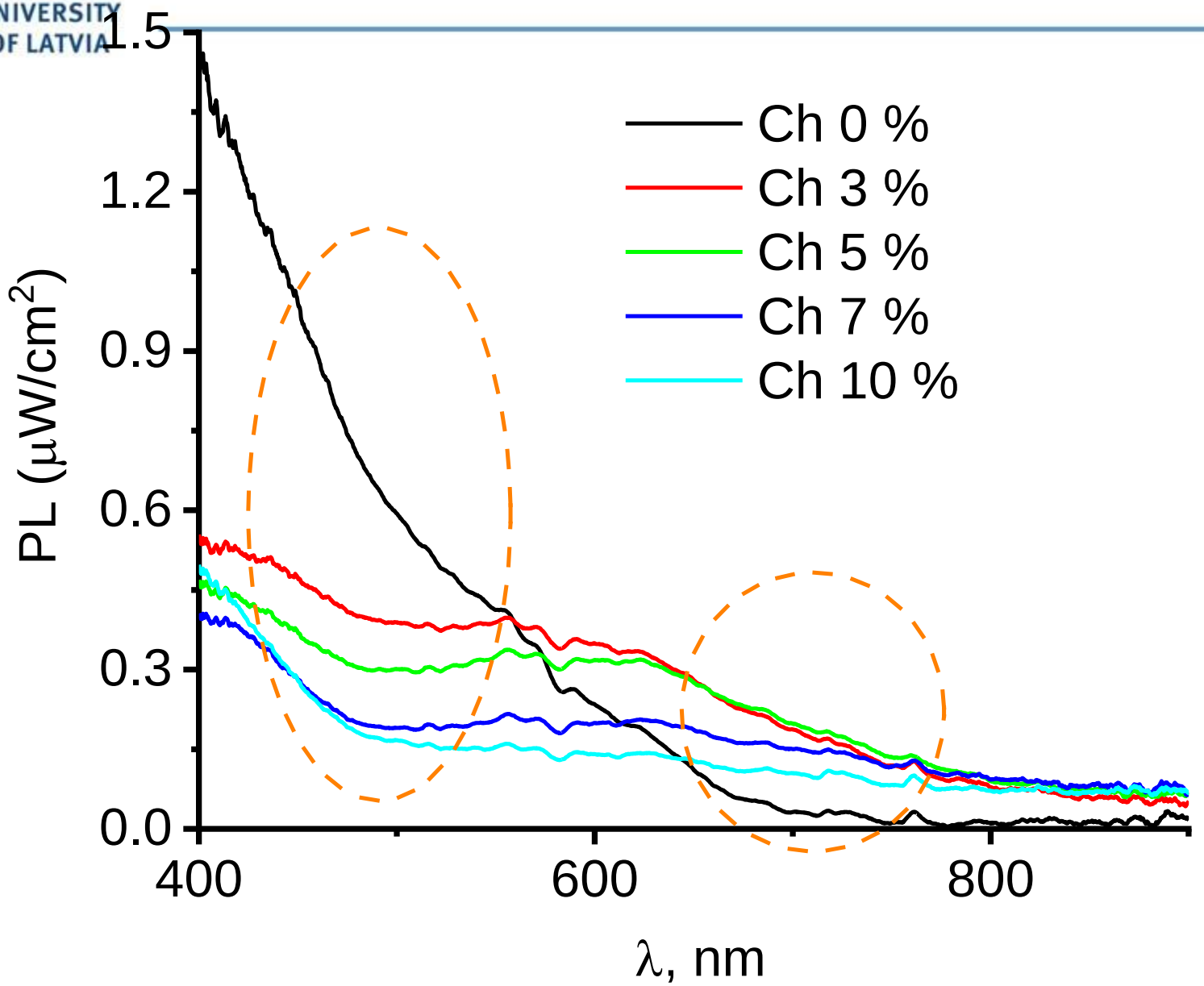
- No changes
- Powder samples required

PEE-Chitosan-Optical absorbance



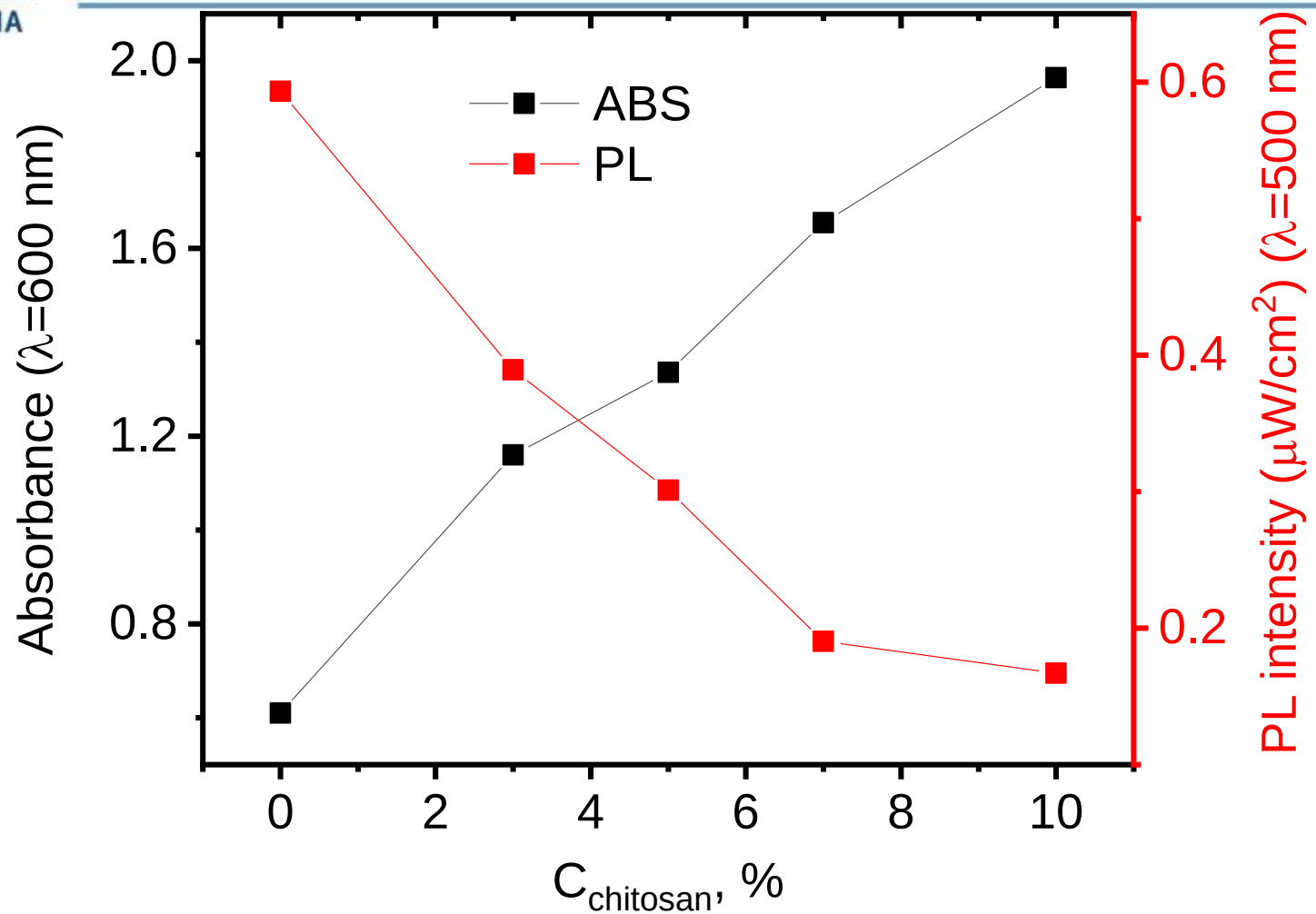
- Strong scattering
- Strong absorption
- Significant difference

PEE-Chitosan-Optical absorbance



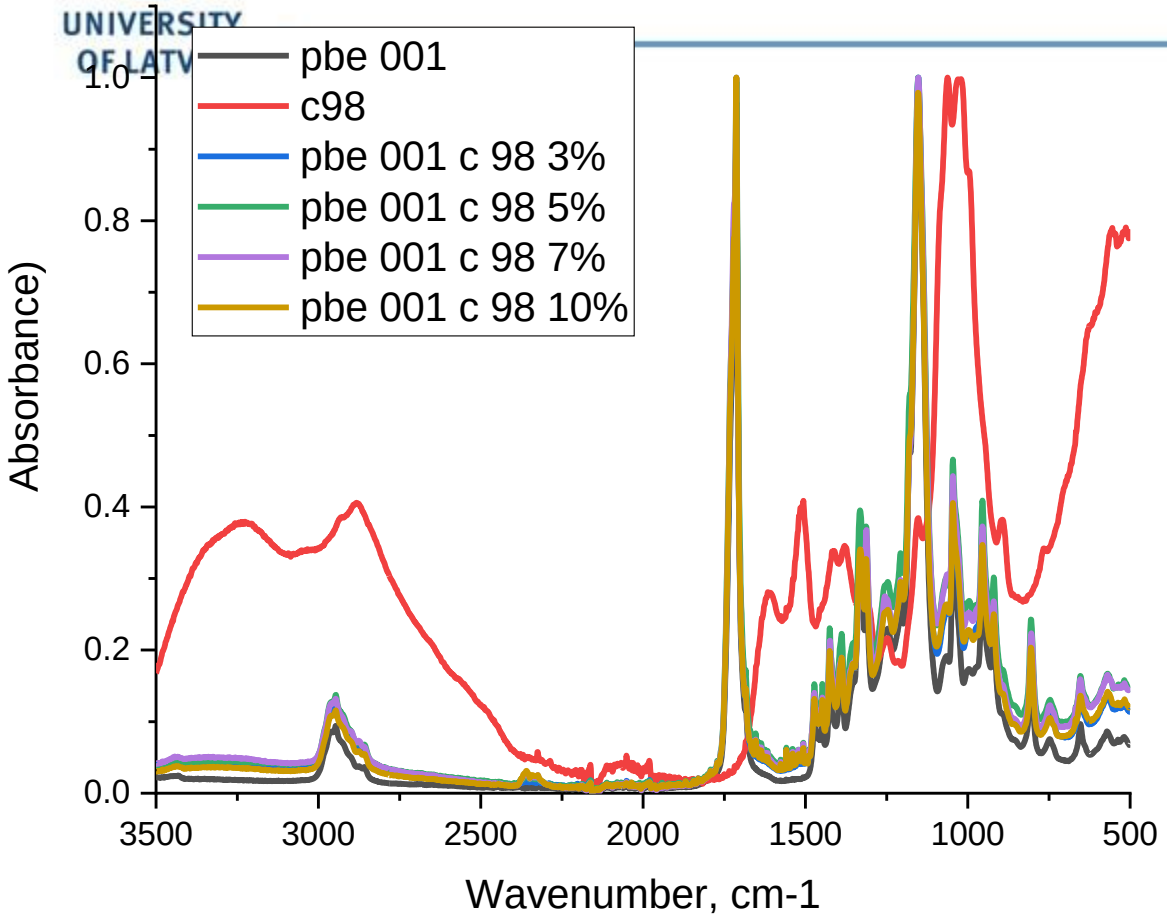
- Strong changes
- Decrease of peaks
- Recognition possible

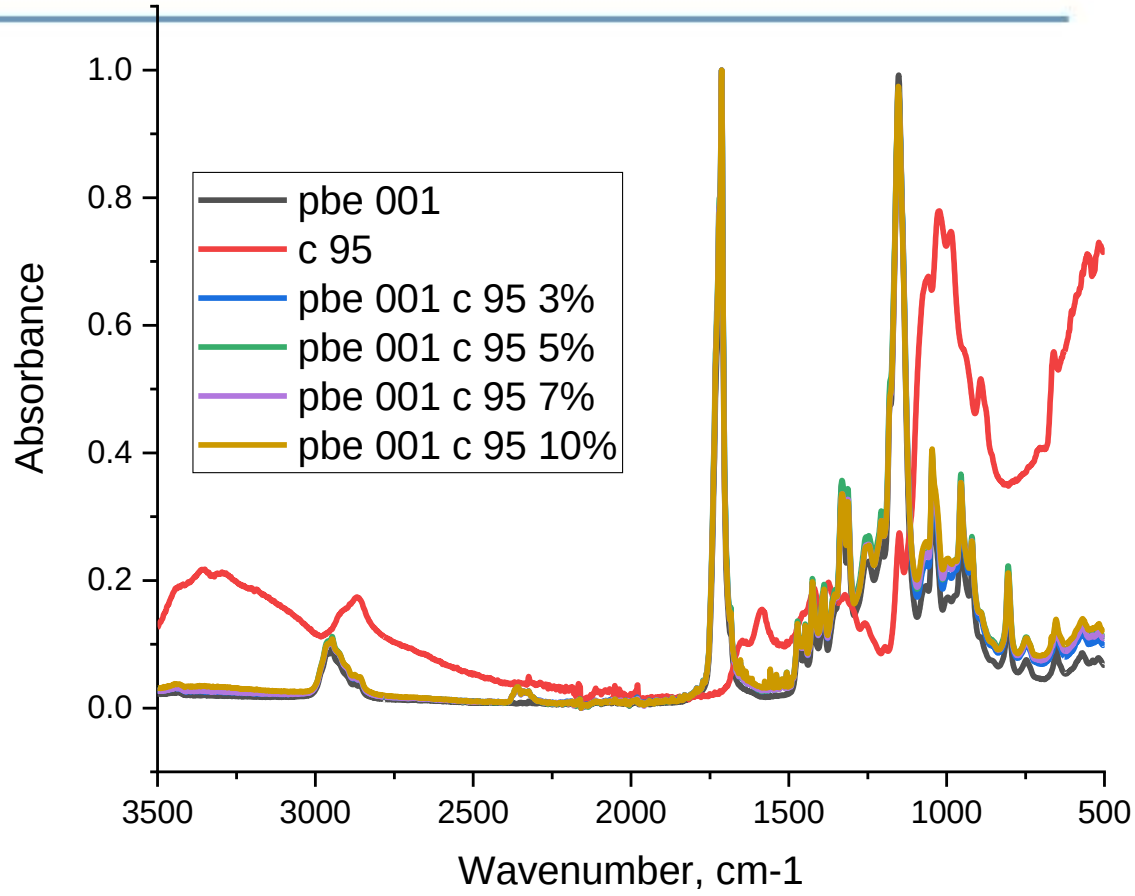
PEE-Chitosan-Analysis



- Two parameter
- Correlative changes
- Significant difference

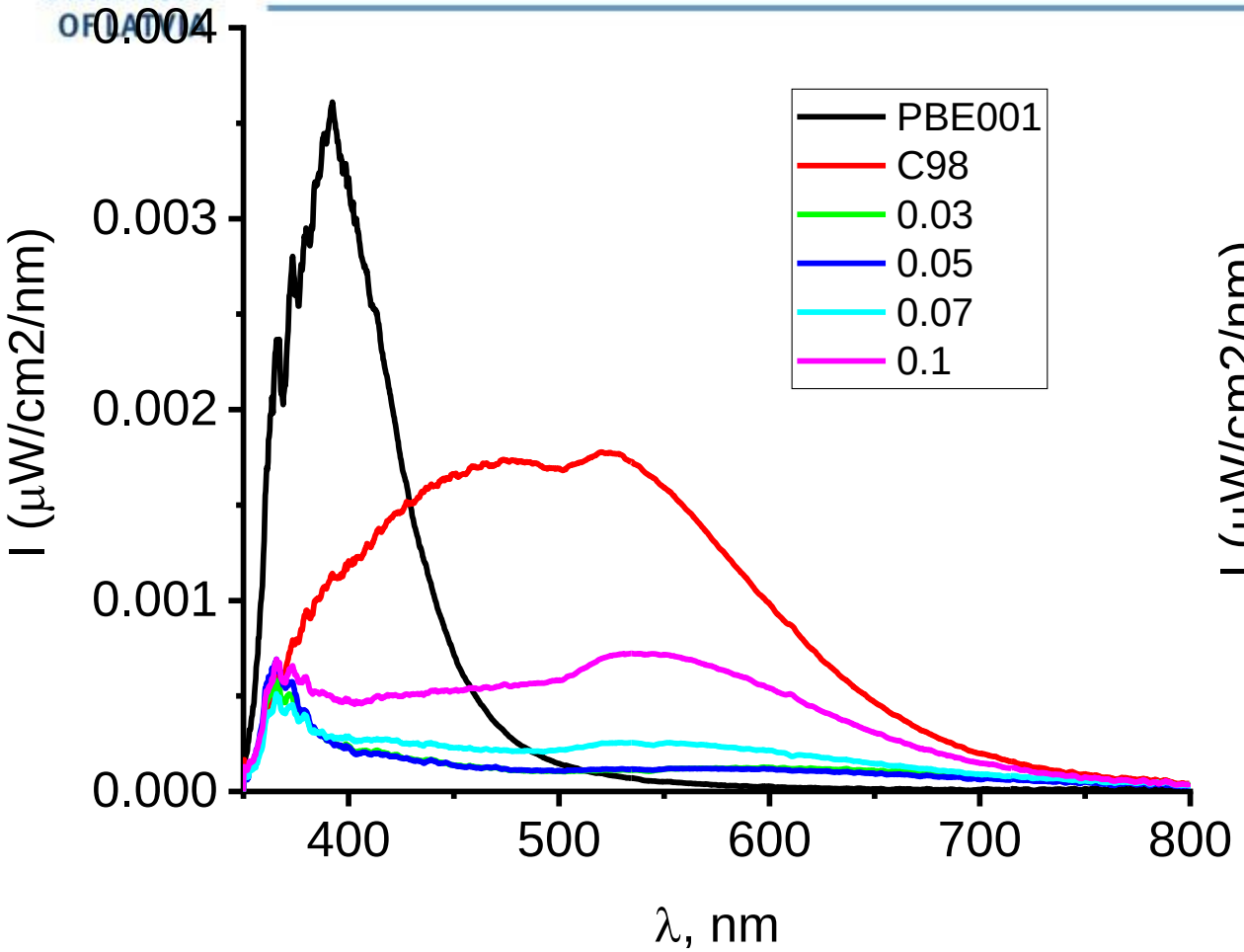
Characterization of PBE-chitosan powder by FTIR

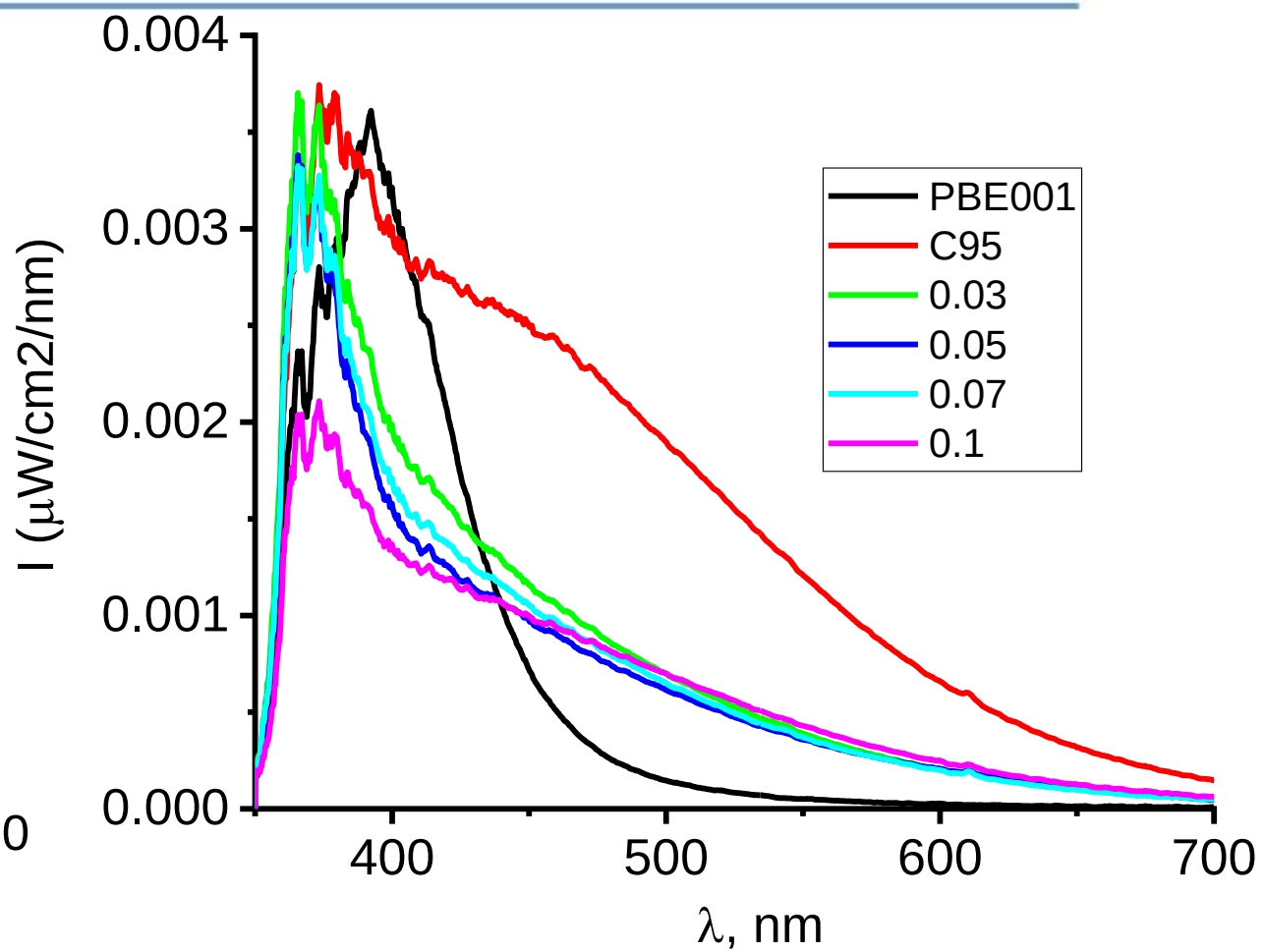




FTIR measurements showed insignificant changes in peak intensities after forming C98 and C95 composites. Redistribution between peaks before and after composite forming point to adding chitosan into PBE matrix

Characterization of PBE-chitosan powder by photoluminescence

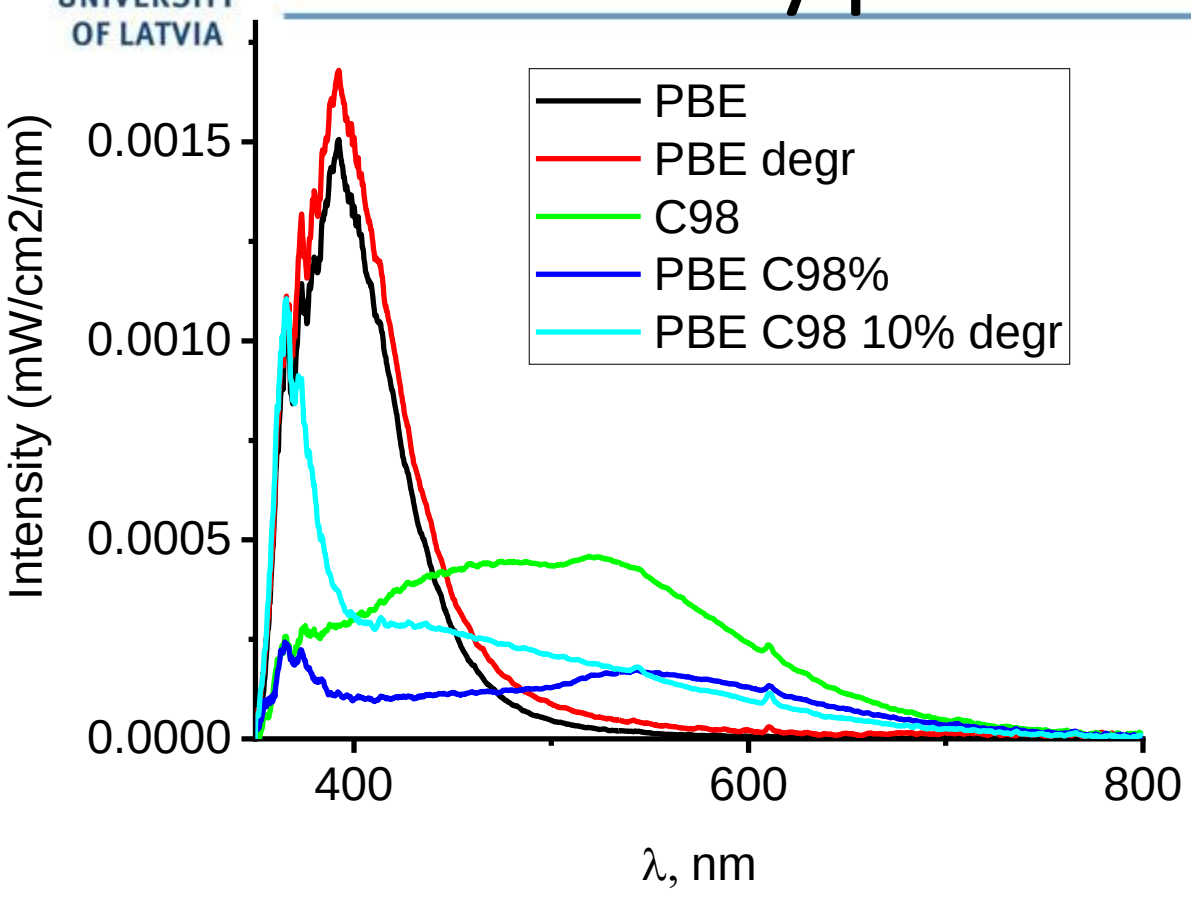


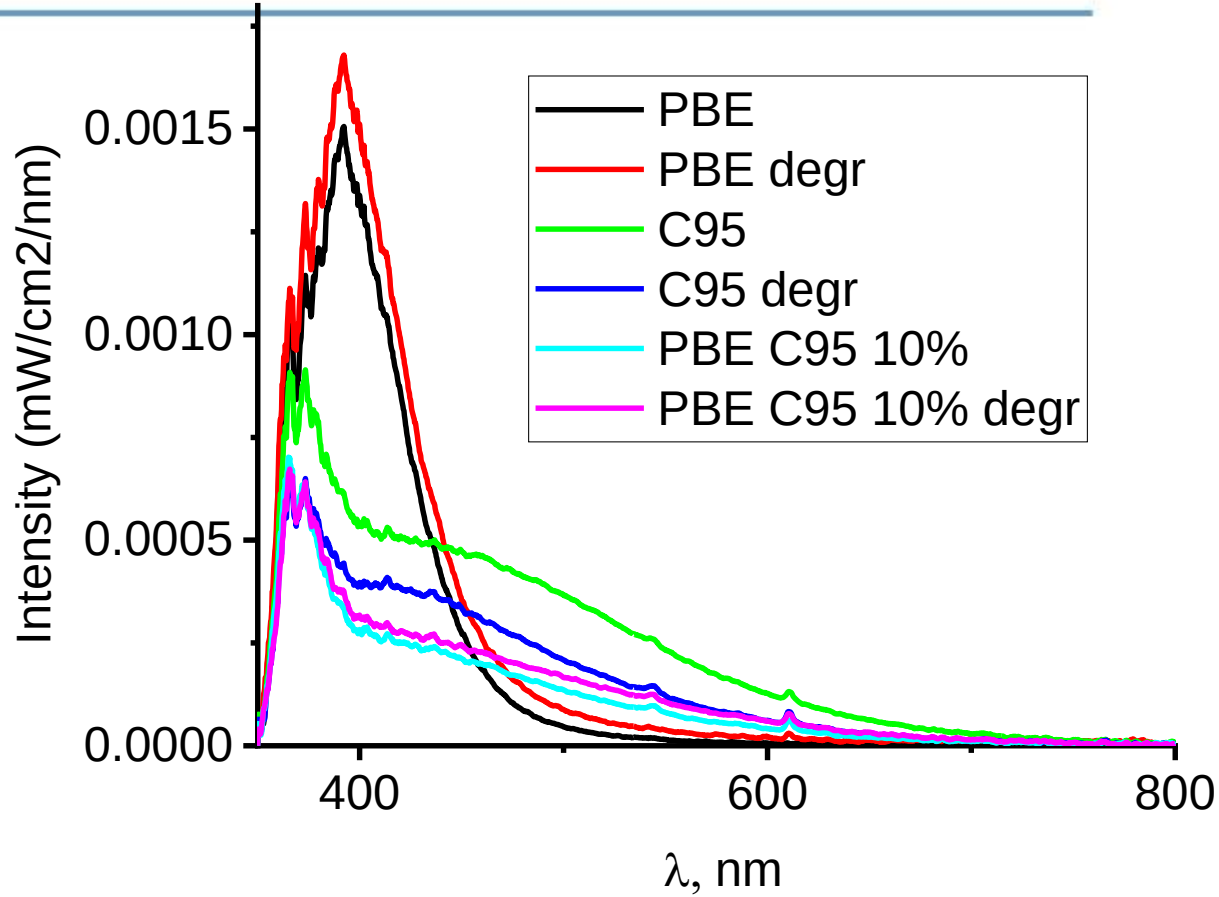


Chitosan C98 makes drastic changes in the spectrum of the composite in the range of 500-700 nm. Concentration dependence of C98 vs PL intensity observed. Spectrum of C95 composite has similar tendency in the range of 550-700 nm. Concentration dependence insignificant

Characterization of PBE-chitosan powder degradation by photoluminescence

UNIVERSITY OF LATVIA





Dgradation tests showed, that PL spectra of C95 and PBE minory changed. Composite materials C98 showed significant changes after degradation. Composite materials C95 showed no changes. More detailed degradation tests for C98 composites are planned.

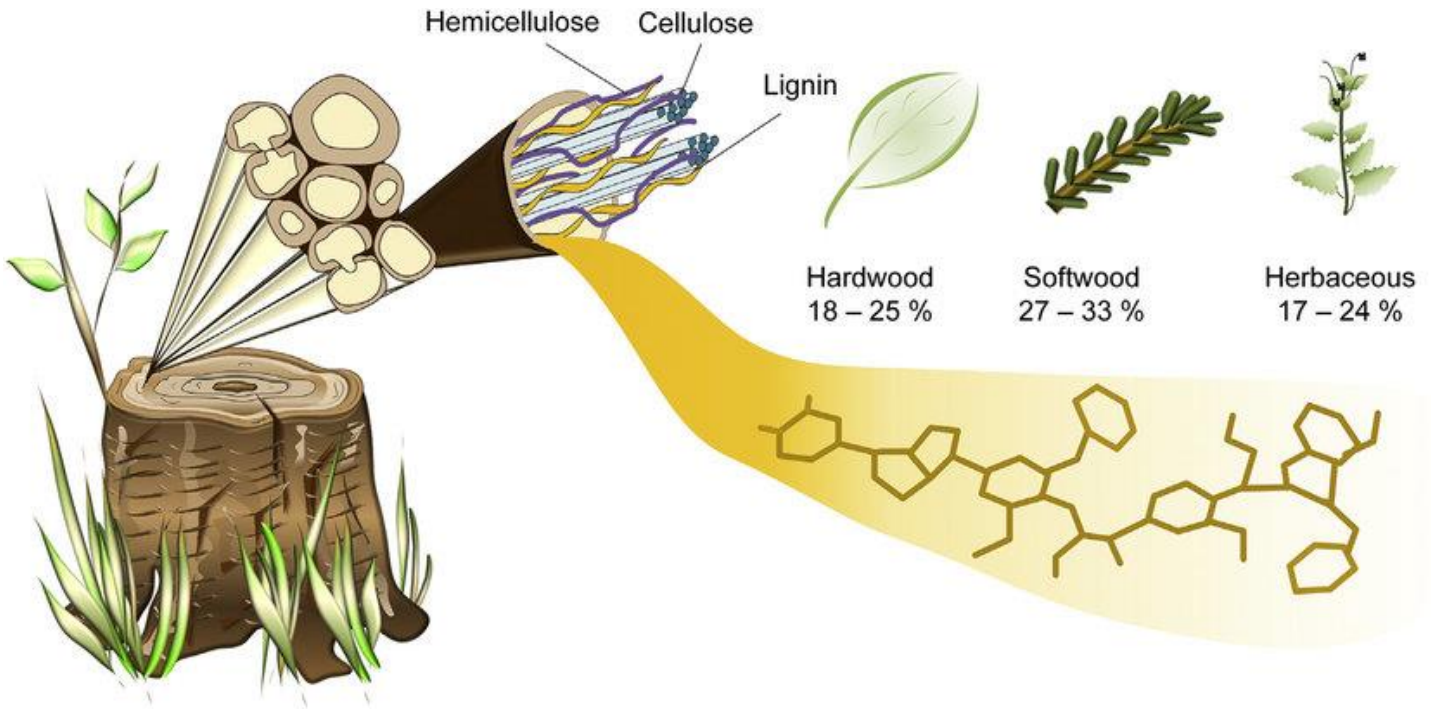
Summary from testing of PEE-Chitosan

- FTIR doesn’t fit well for polymeric samples. Only PEE measurements
- Raman didn’t provide info – sample burning
- Optical methods show difference between PBE and PBE-chitosan samples
- Chitosan particles increase absorption and scattering. Clear dependence in NIR range
- Two component analysis
- Only C98 showed good biodegradable properties
- New bio degradation tests

UNIVERSITY OF LATVIA

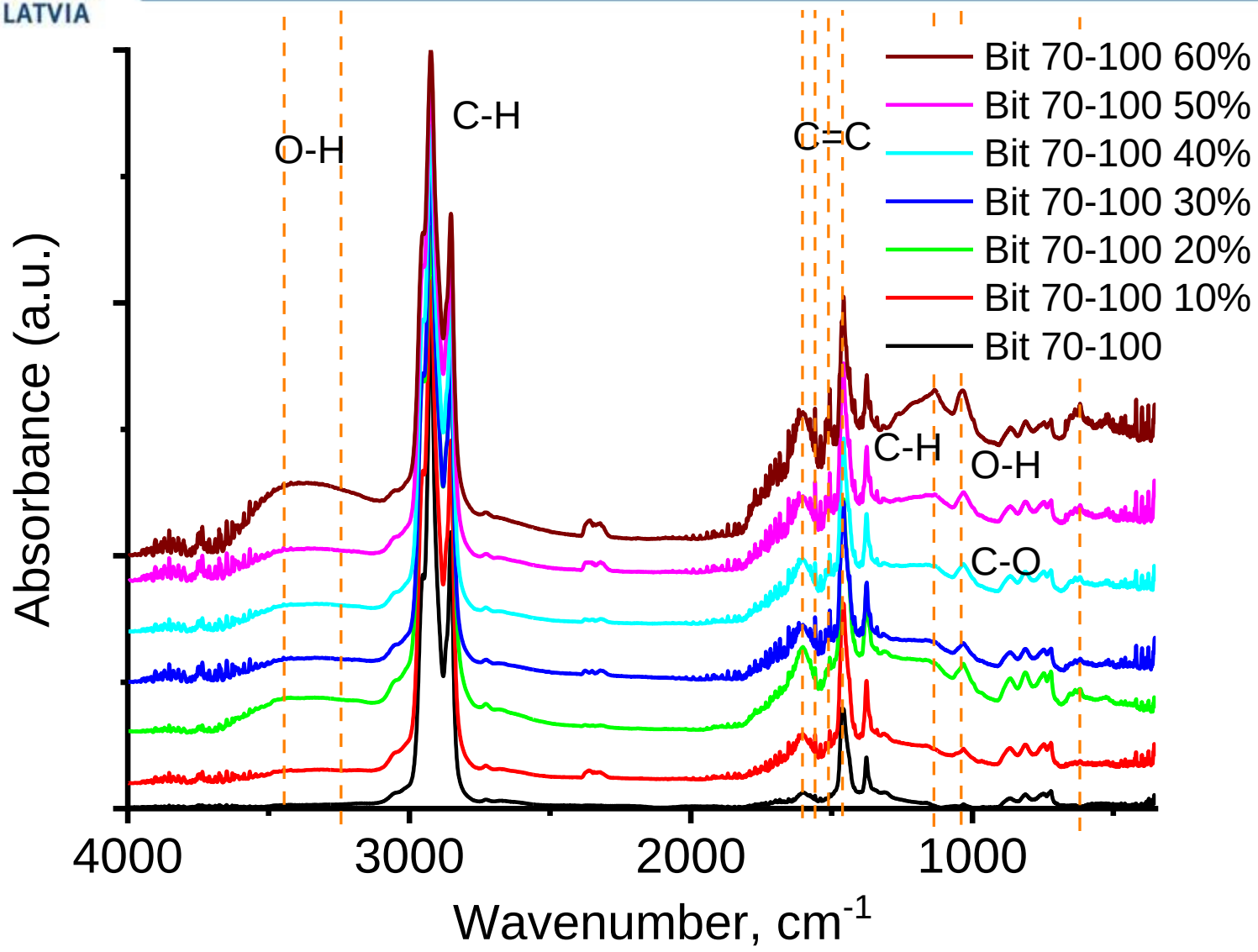
WP4 Smart asphalt coating: lignin modified bitumen

Lignin



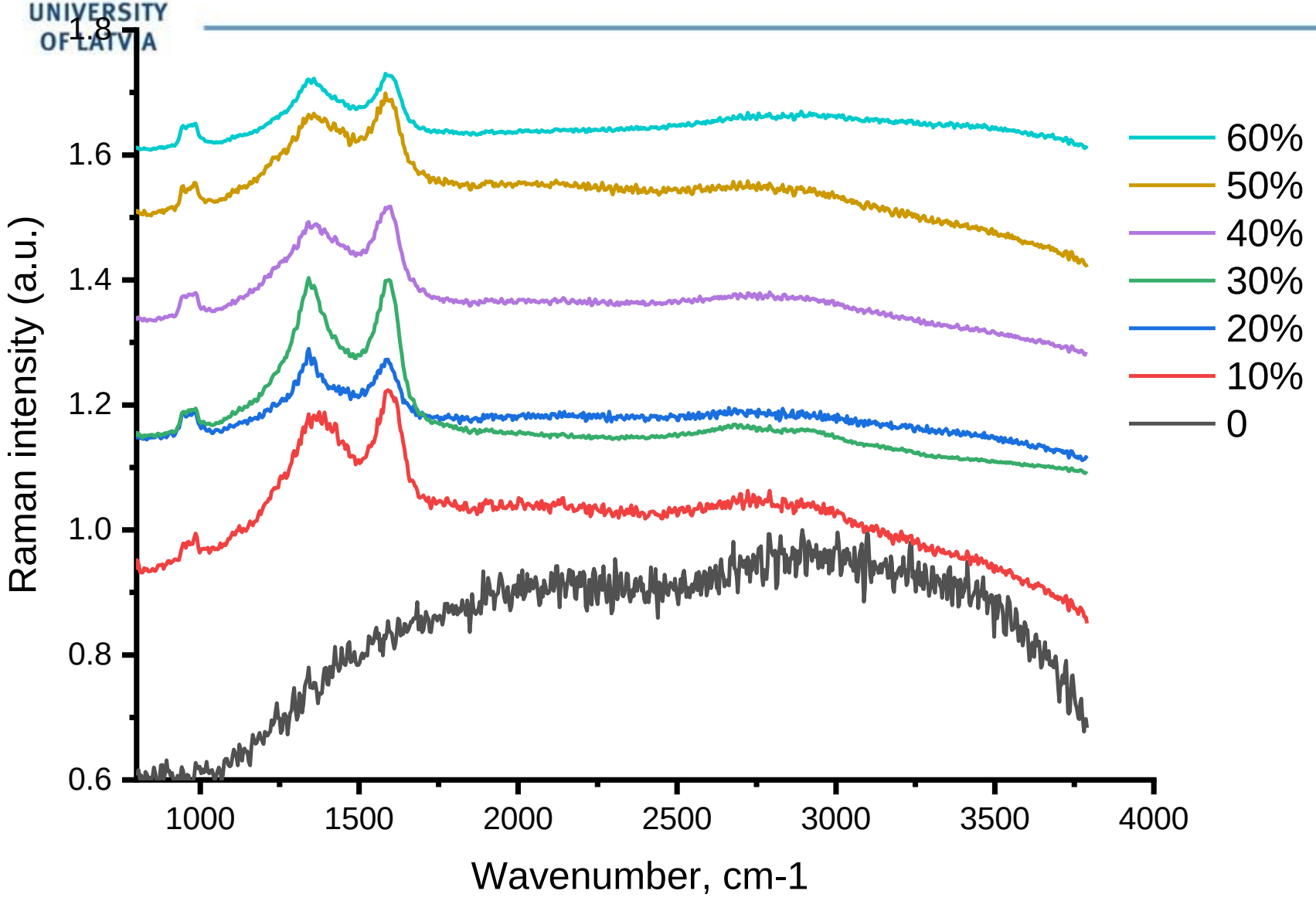
- Wood by product
- Polyphenolic compound
- Anti-oxidative properties

Bitumen-FTIR



- Big changes
- New peaks
- Enhancement of other peaks

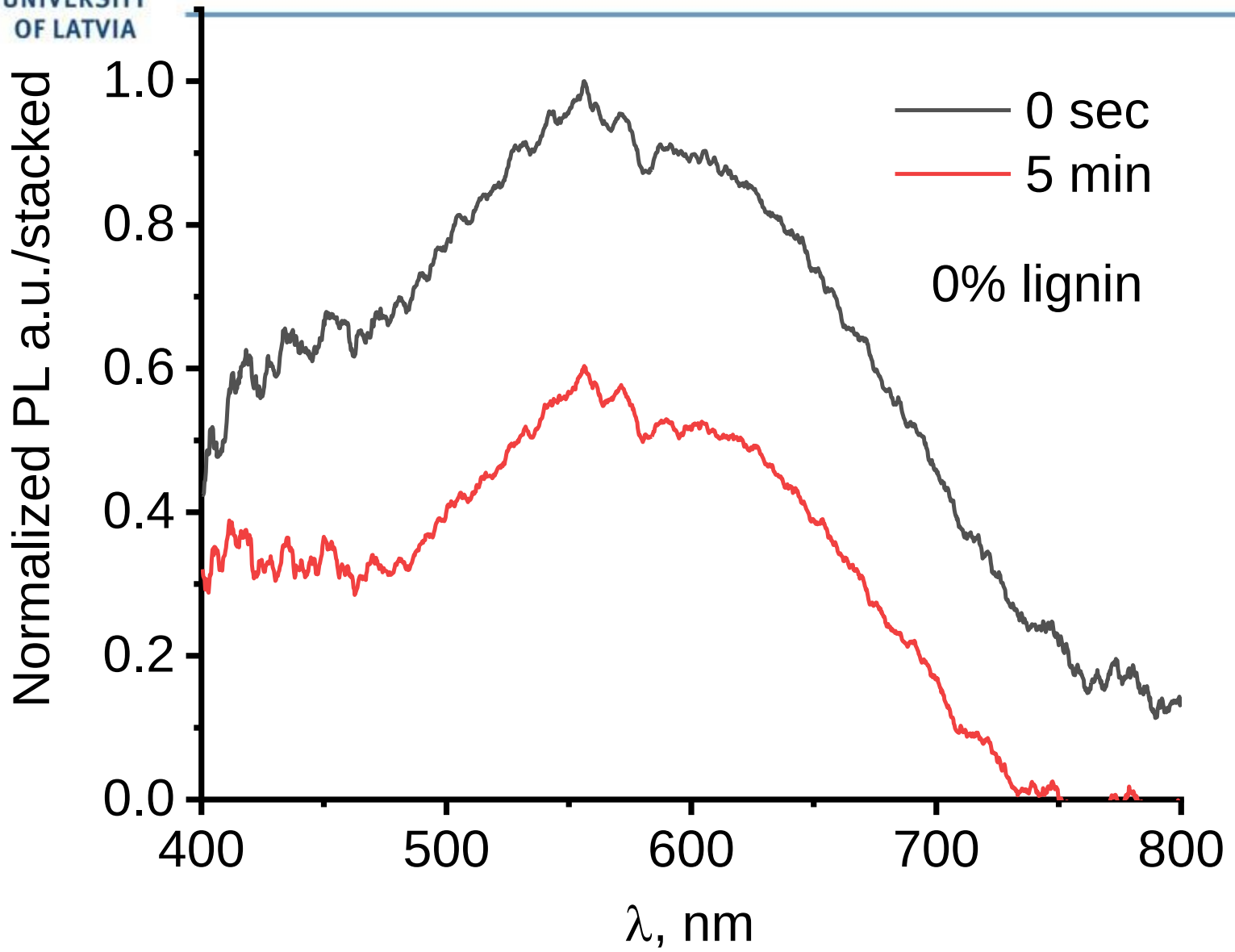
Bitumen - Raman spectra



- Big changes
- New peaks (1347 cm-1 (syringyl (S)),

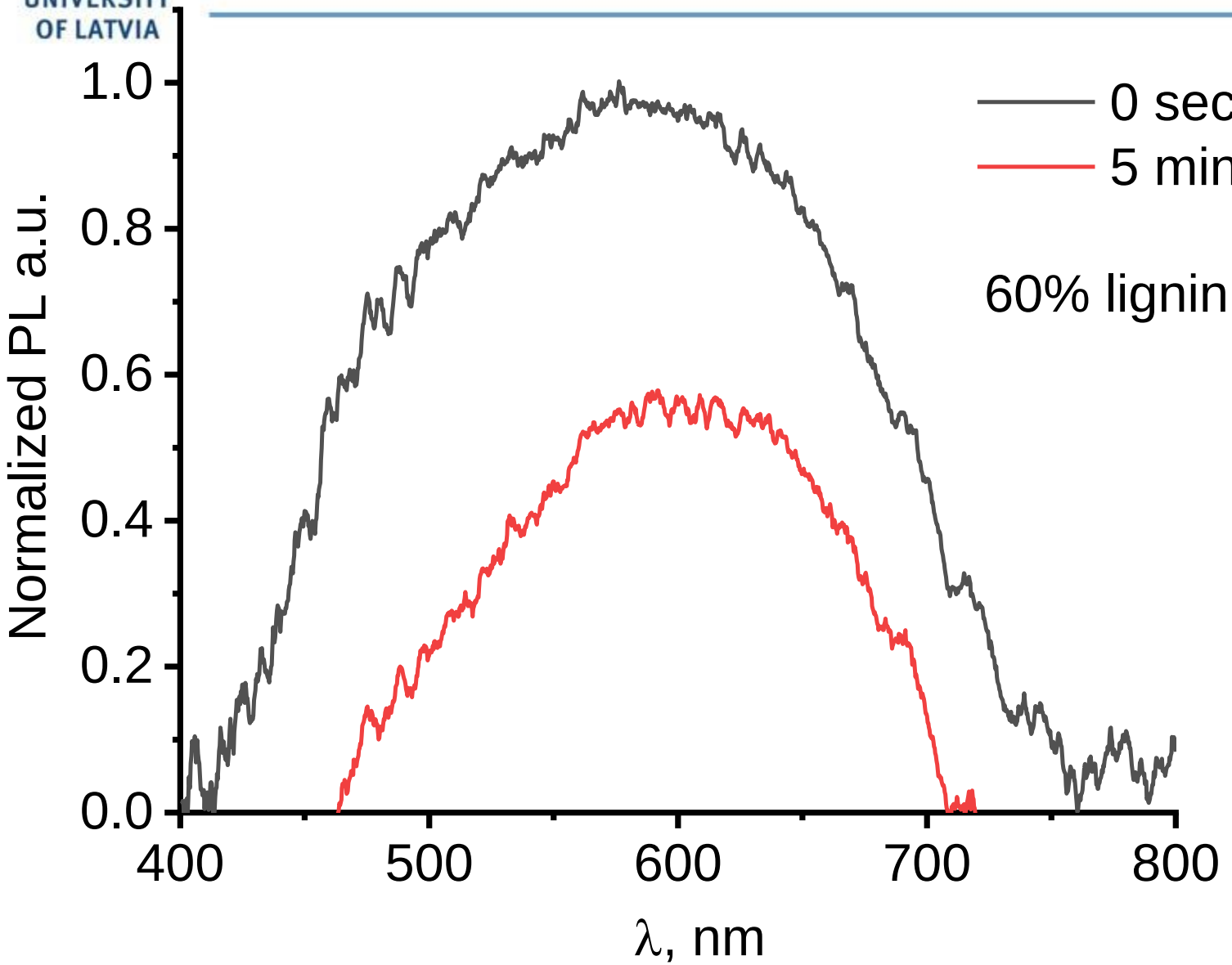
1588 cm-1 (aryl stretching mode

Bitumen-PL



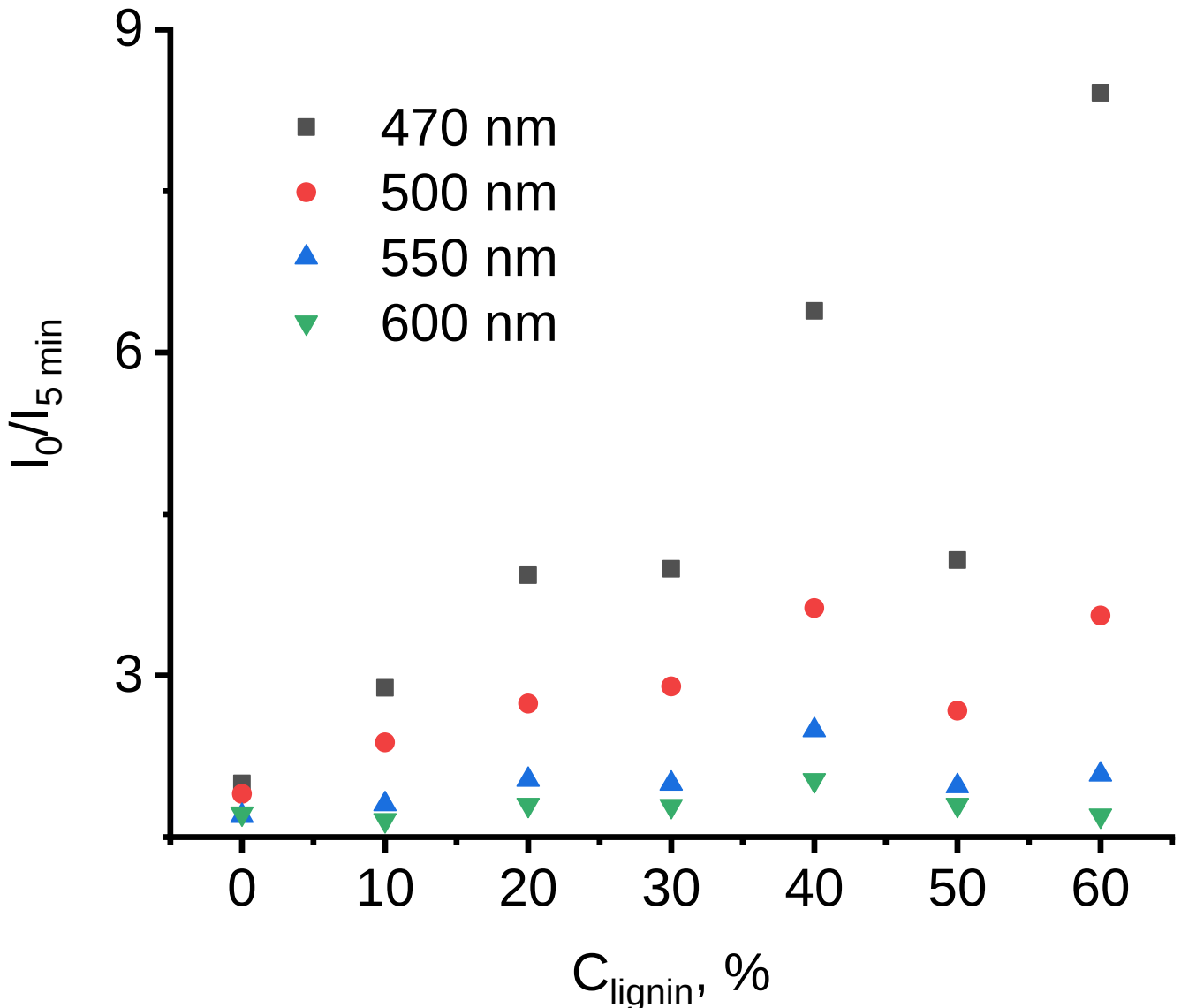
- UV exposition (300 nm, 0.5 mW)
- PL quenching
- No change of spectra

Bitumen-PL



- UV exposition (300 nm, 0.5 mW)
- PL quenching
- Change of spectra
- Absorption/Reaction

Bitumen-PL analysis



- PL mapping ratio initial to 5 min exposition to UV

Summary from testing of Bitumen

- Hard to prepare samples with same thickness and surface roughness
- FTIR fits well for Bitumen testing. New absorption band appeared after lignin adding (OH, C=C, C=O, benzene ring, etc)
- Raman is a fingerprint for bitumen testing. New peaks appear when lignin is added (vibrations in benzene ring)
- Lignin changed emission spectrum of Bitumen. Red shift of peak position and stronger decrease of emission intensity.
- Strong changes in 470 nm and 600 nm

Next steps within/after VPP

- New collaboration with KKI (catalysis of polymers)
- New collaboration with RSU (pharmaceutics)
- New collaboration with RTU (polymer for food packaging)
- New collaboration with CFI (SERS templates for sensors)

UNIVERSITY OF LATVIA

Paldies/
Thank you