“FTIR for detection of impurities in NaI(Tl), CsI(Tl) and CsI(Na) crystalline scintillators”

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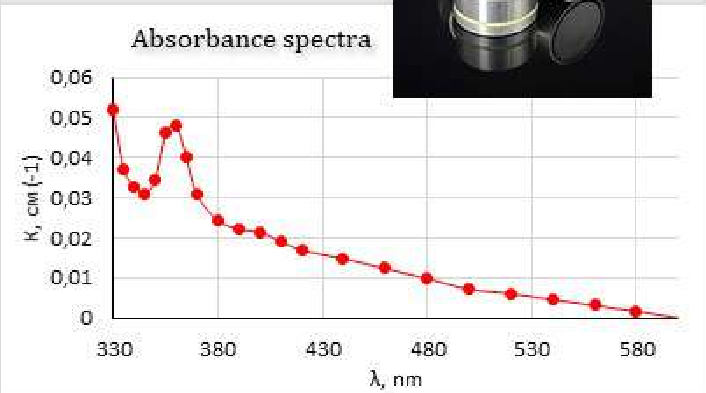
NaI(Tl), CsI(Tl) and CsI(Na) crystalline scintillators

NaI(Tl)

- \+ Classic scintillator for detecting gamma-radiation.
- \+ High luminescence efficiency, wide variety of sizes and geometries and relatively low-cost.
- \+ Great light output, good radiation hardness.
- – Hygroscopicity.



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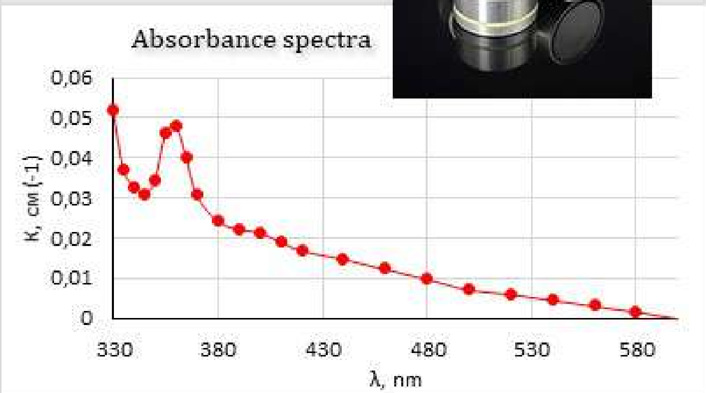
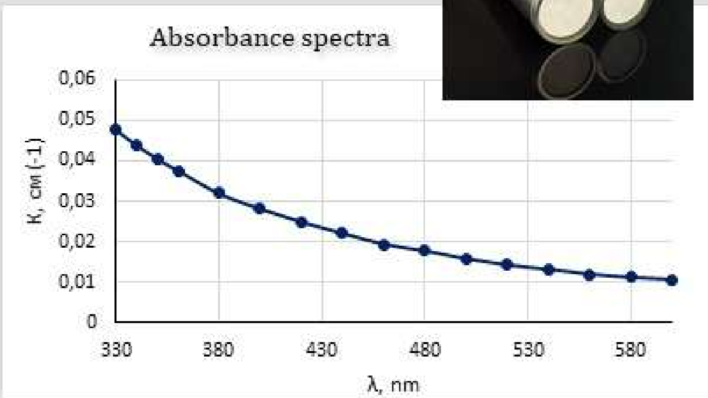


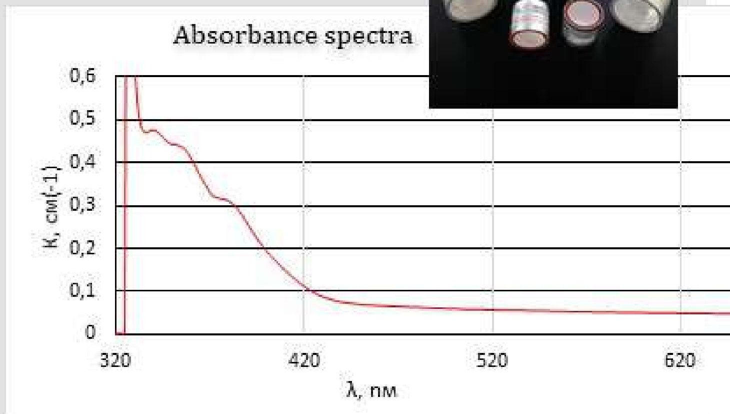
CsI(Tl)

- \+ Has a larger cross-section of the gamma-radiation photoabsorption.
- \+ Not hygroscopic, high mechanical hardness.
- \+ Relatively good radiation hardness.
- \+ Can be obtained with low afterglow for application in tomo[...] systems.



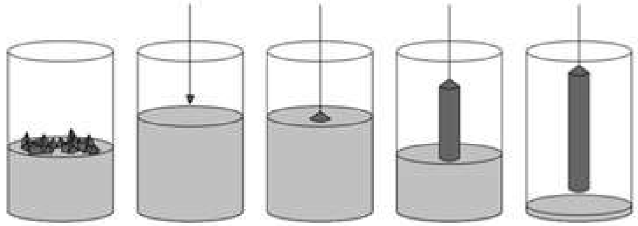
CsI(Na)

- \+ Good alternative for NaI(Tl) in many standard applications.
- \+ High mechanical strength and thermal stability.
- \+ Is used in the experimental high-energy physics as scintillation elements of electroma[...] calorimeters.



NaI(Tl), CsI(Tl) and CsI(Na) crystalline scintillators

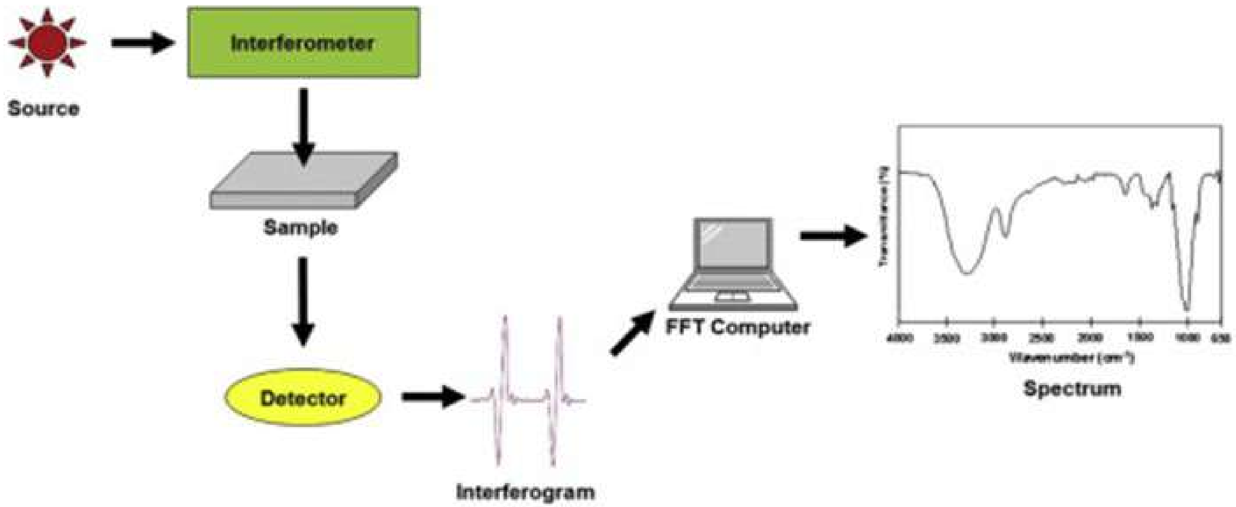
NaI(Tl)	CsI(Tl)	CsI(Na)
		



Czochralski method

	CO_3	CNO	SO_4	H_2O
Reduction of radiation resistance	+		+	
Appearance of turbidity in the crystal	+			+
Degradation of the light output observed after prolonged irradiation	+			+
Reduction in light output	+	+	+	+
Deterioration of crystal structure	+			
Maximum permissible concentration, mol %	$5 \cdot 10^{-5}$	$1 \cdot 10^{-3}$	$5 \cdot 10^{-5}$	none

FTIR (Fourier-transform infrared spectroscopy) for detecting impurities



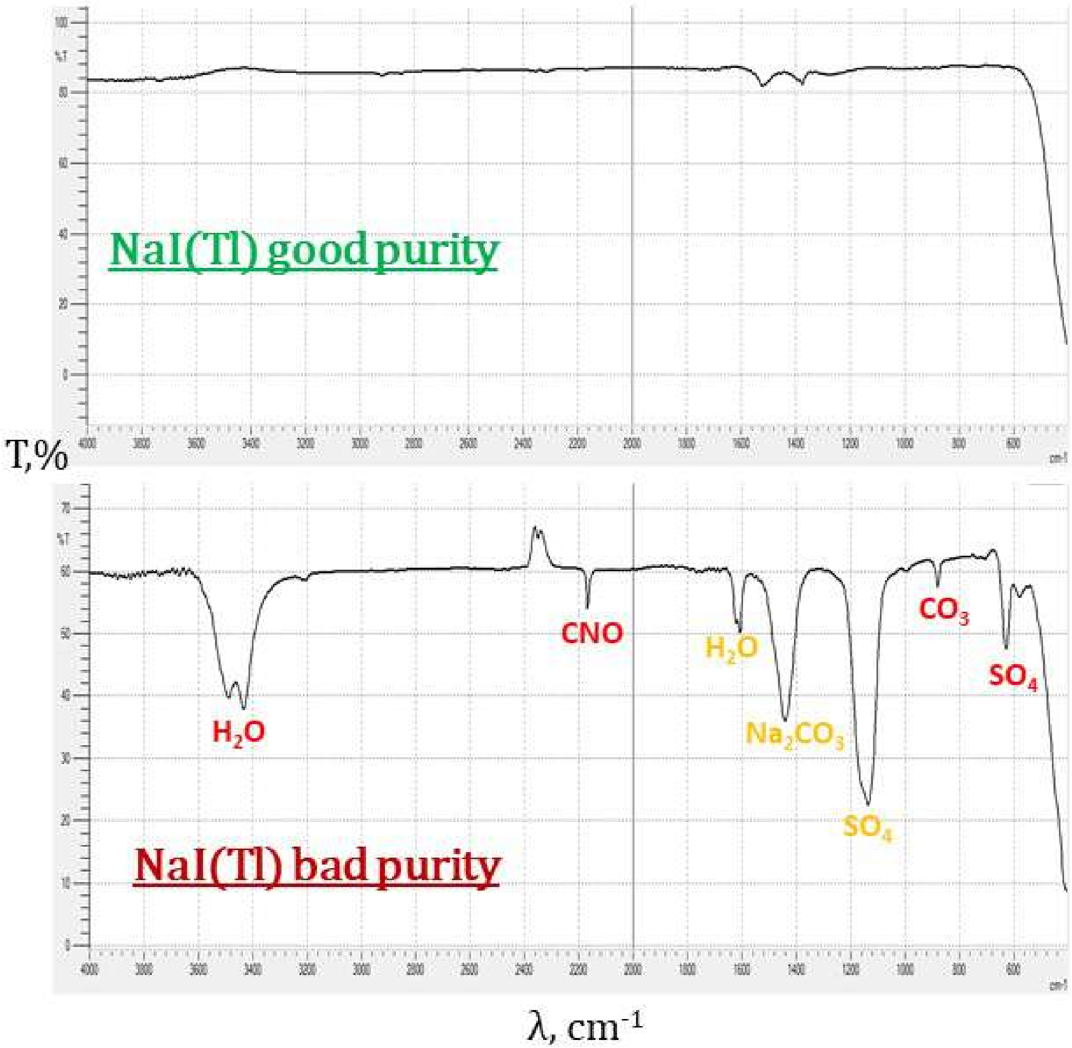
Beer-Lambert Law:

$$lg\frac{I_0}{I} = \varepsilon l c$$

where:

- I_0 – incident intensity;
- I – transmitted intensity;
- ε – molar absorption coefficient;
- l – optical length;
- c – concentration (mol dm^{-3}).

IR spectra of NaI(Tl), CsI(Tl) and CsI(Na) crystalline scintillators



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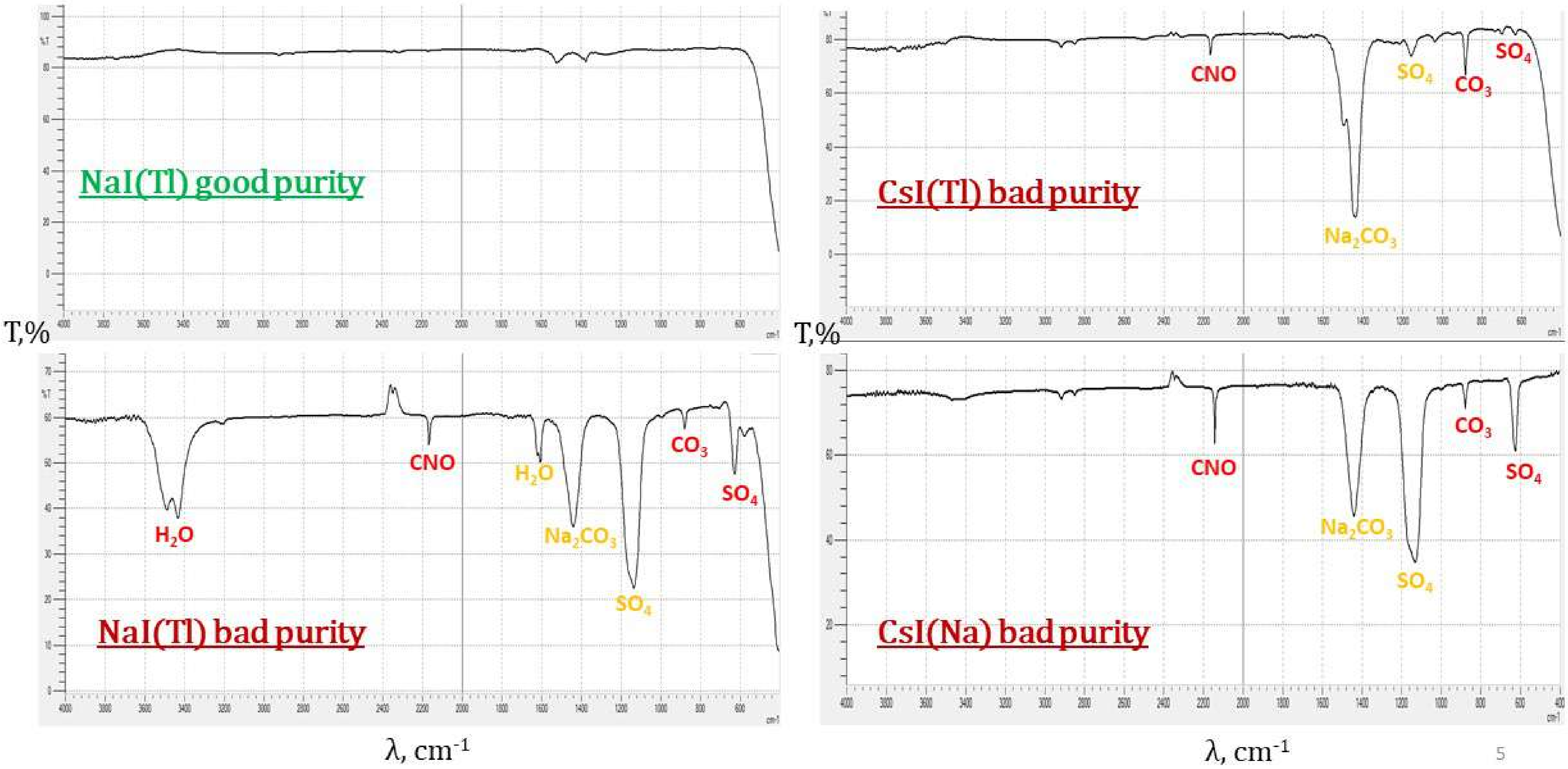
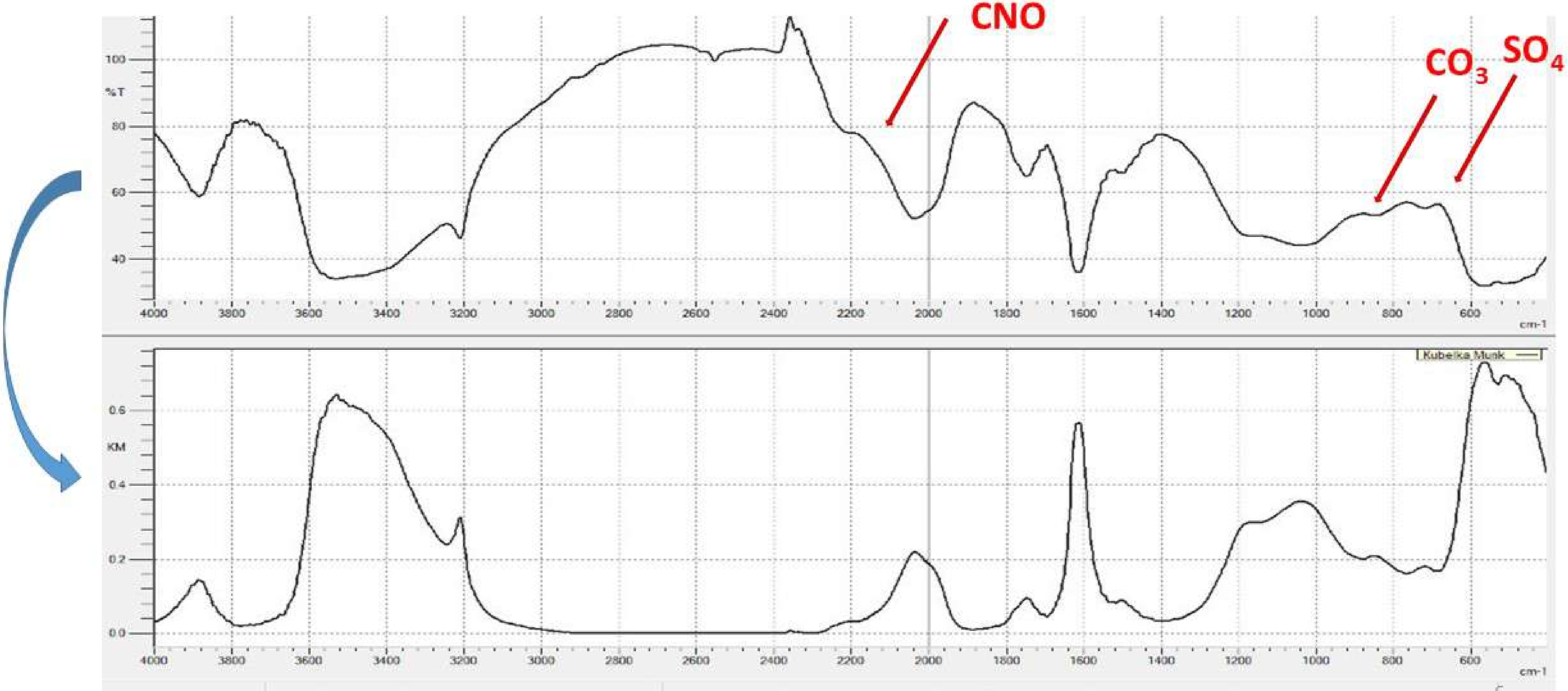


IR spectra of NaI(Tl) powder and Kubelka-Munk theory

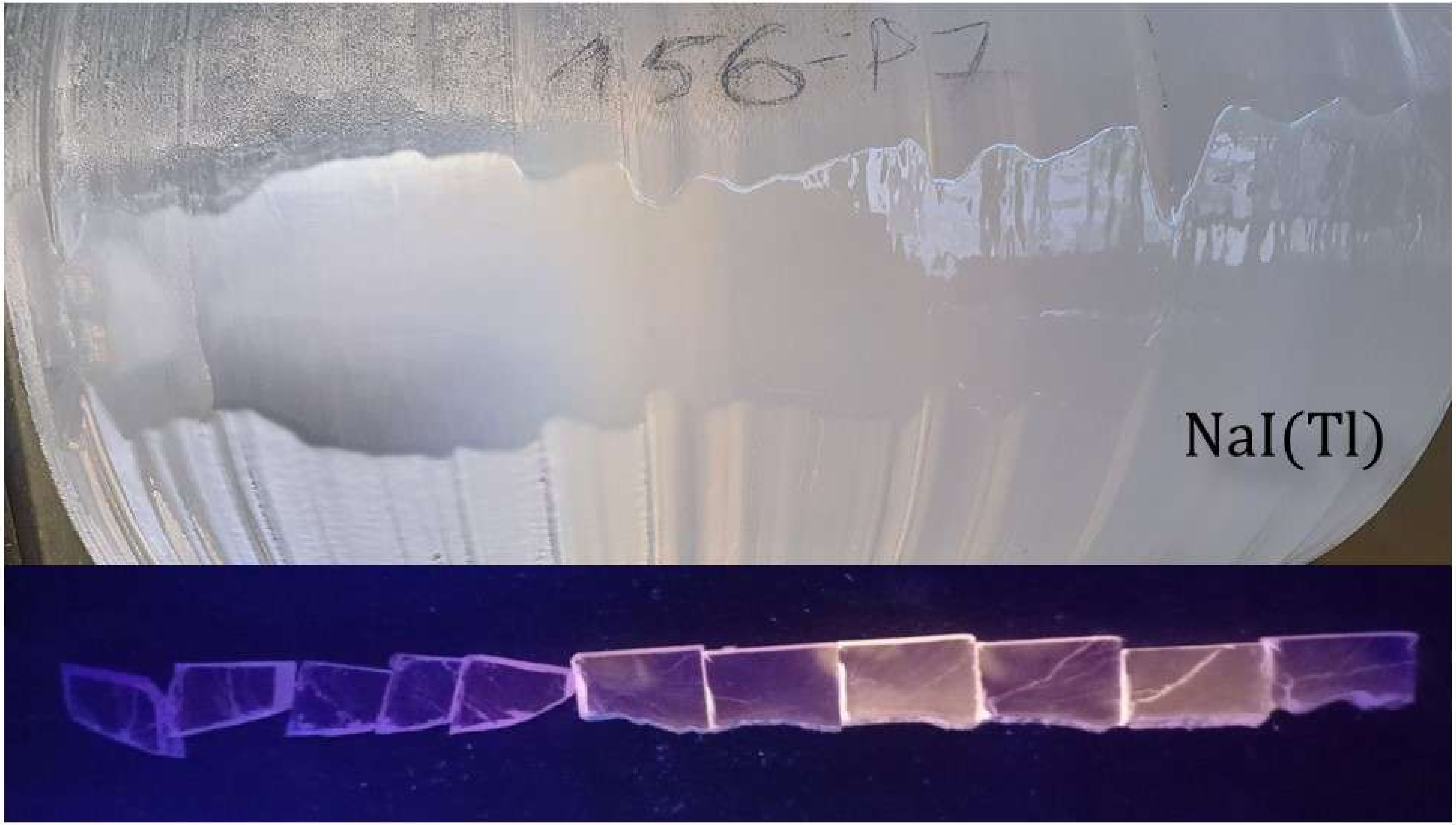
IR beam scattering on the powder surface on each wavelength is connected with the concentration of impurities.



λ, cm^{-1}

Influence of impurities on the scintillation properties of crystals NaI(Tl), CsI(Tl) and CsI(Na)

Excess carbonates are observed visually and under the UV light.



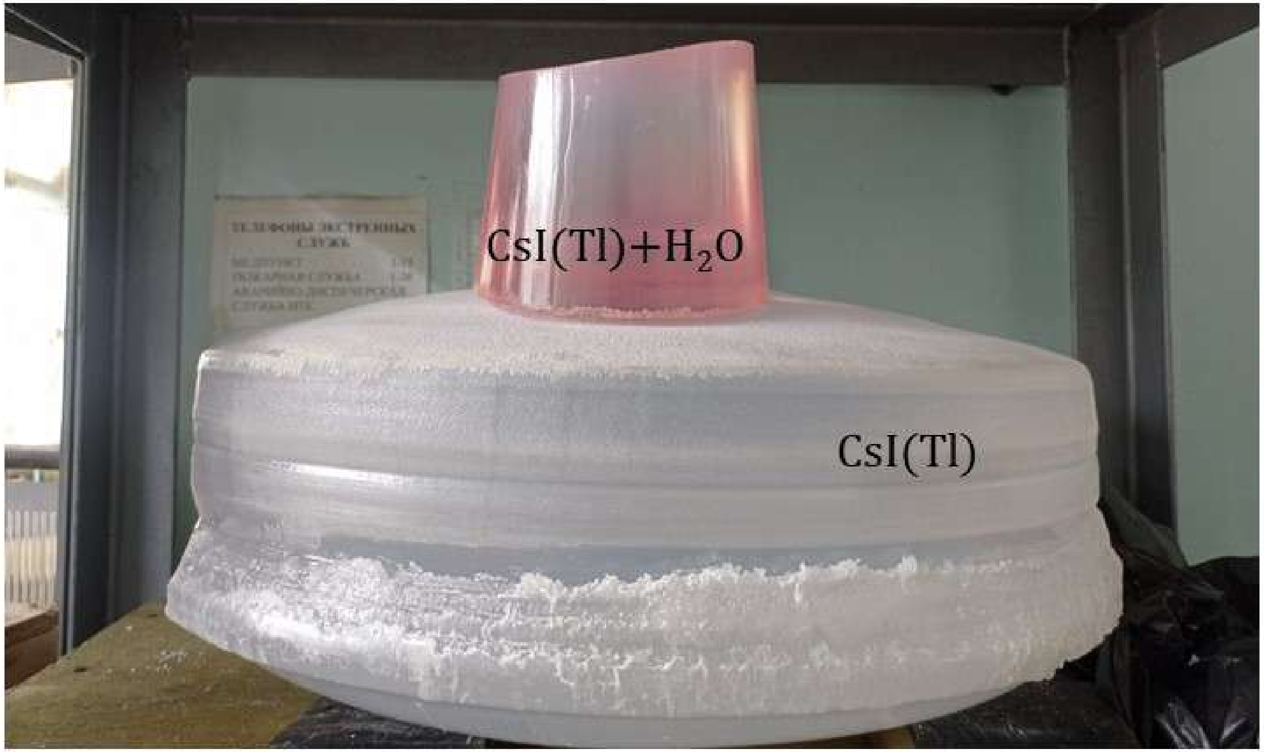
Influence of impurities on the scintillation properties of crystals NaI(Tl), CsI(Tl) and CsI(Na)

Excess carbonates and water influence on the scintillator coloring after its irradiation.

NaI(Tl) with excess CO_3

Etalon

Two-day UV light irradiation



Influence of impurities on the scintillation properties of crystals NaI(Tl), CsI(Tl) and CsI(Na)

Impurities also affect the appearance of the block structure of the crystal.

Conclusions

- Detecting impurities is critical for maintaining the performance and reliability of crystalline scintillators.
- Impurities can significantly affect the light output, radiation resistance, and overall efficiency of scintillators.
- Infrared spectroscopy is a precise and effective method for measuring impurities in scintillators.