MOLECULAR EMITTERS AS A TUNABLE LIGHT SOURCE FOR OPTICAL MULTISENSOR SYSTEMS

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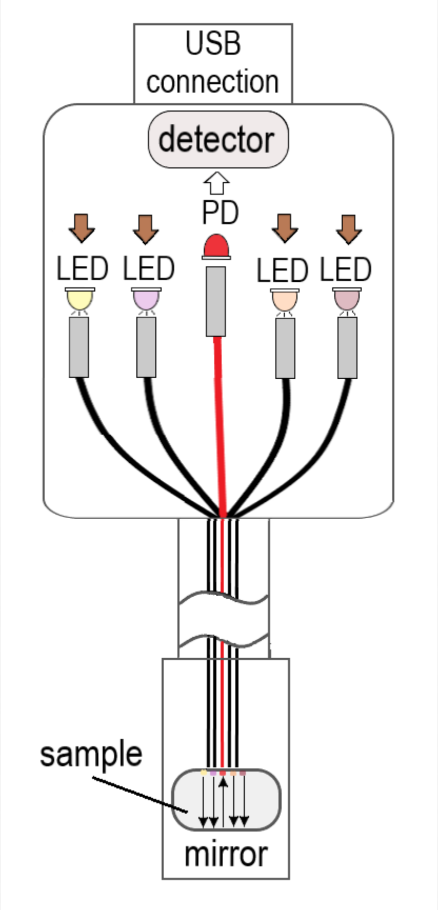
OPTICAL MULTISENSOR SYSTEM (OMS)

- Multisensor system – an analytical device
  - composed of two or more sensors
  - optimized for a particular analytical task
  - employs chemometrics to maintain accuracy

- OMS composed of
  - light sources
  - photodetectors
  - optical fibers
  - 3D-printed parts, etc.

- Advantages
  - inexpensive
  - portable
  - on-site/on-line implementation

Example of OMS [a]



[a] *Surkova A., Bogomolov A., Legin A., Kirsanov D. ACS Sensors. 2020; 5:2587−2595. doi: 0.1021/acssensors.0c01018*

PURPOSE OF THIS STUDY

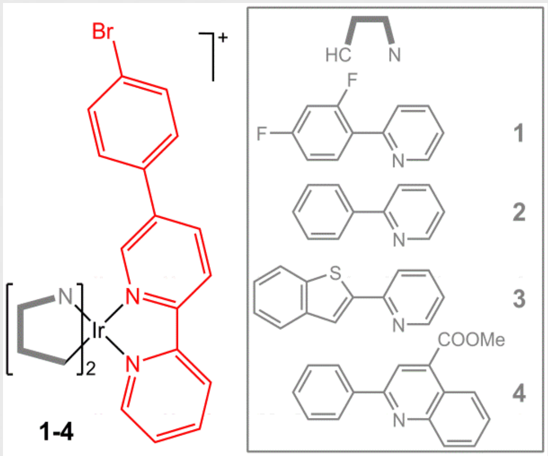
- To develop OMS prototype based on molecular emitters as a tunable light source
- To study a real-life applicability of the developed prototype

MOLECULAR EMITTERS AS A LIGHT SOURCE

- Properties
  - laser diode excites the emission of molecular emitters
- Requirements to choose emitters
  - absorption spectrum must not overlap with emission spectrum
  - excitation radiation must fit into the absorption maximum
  - brightness (quantum yield of emission)
  - emission wavelength in solid phase
- Advantages
  - high versatility
  - short analysis time
  - adjustment of the emission wavelength for a specific application

EXAMPLES OF MOLECULAR EMITTERS

Ir(III) complexes



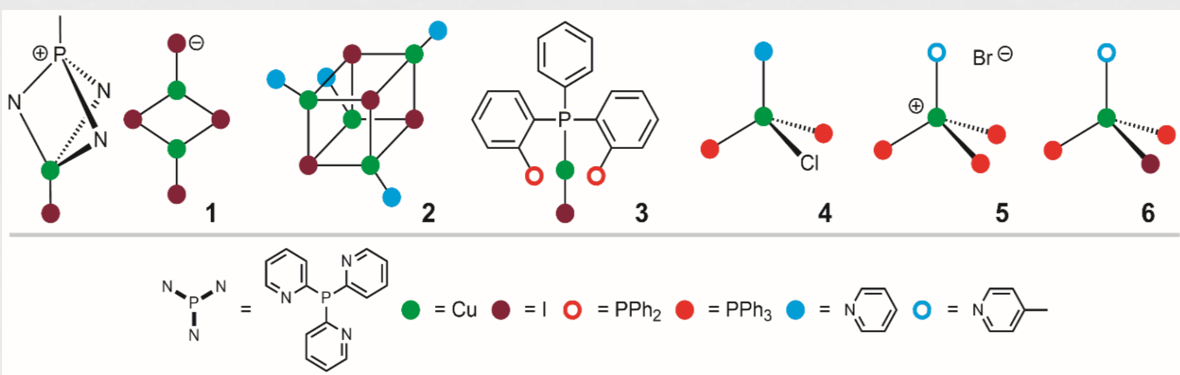
$[Ir(dfppy)_2(bpbpy)]PF_6$ (1)

$[Ir(ppy)_2(bpbpy)]PF_6$ (2)

$[Ir(pybt)_2(bpbpy)]PF_6$ (3)

$[Ir(mpqc)_2(bpbpy)]PF_6$ (4)

Cu(I) complexes



$[Cu(MePPy_3)I]_2[Cu_2I_4]$ (1)

$[Cu_4I_4(py)_4]$ (2)

$[Cu(Tpdp)I]$ (3)

$[CuCl(PPh_3)_2(py)]$ (4)

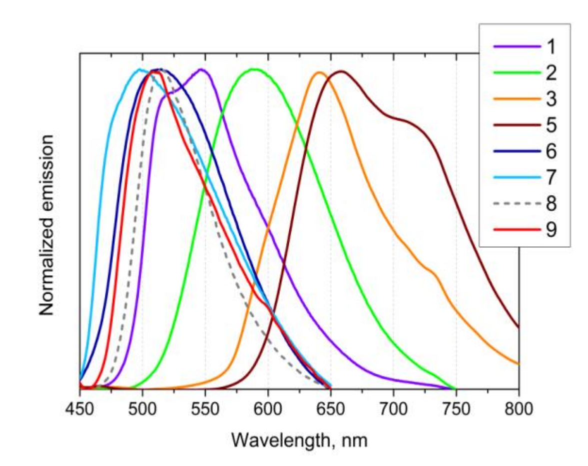
$[Cu(PPh_3)_3(4\text{-}Mepy)]Br$ (5)

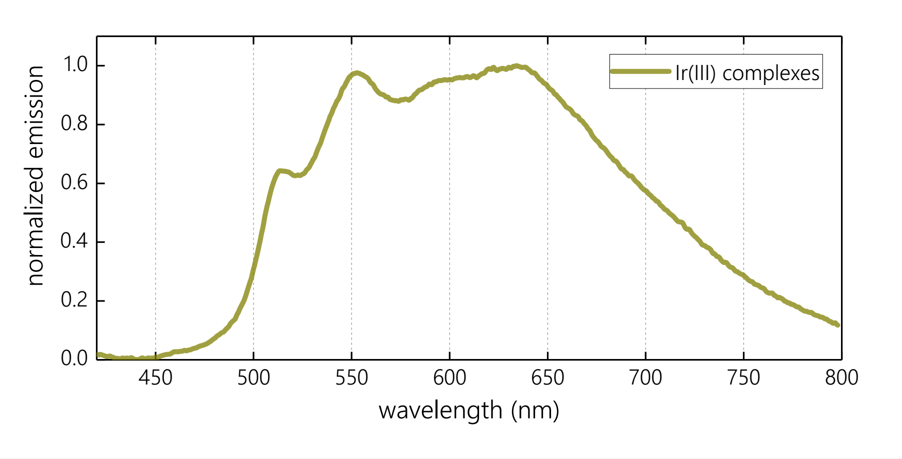
$[CuI(PPh_3)_2(4\text{-}Mepy)]$ (6)

MOLECULAR EMITTERS AS A LIGHT SOURCE

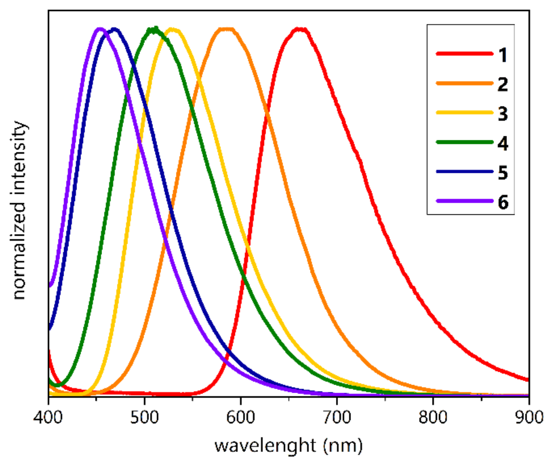
Emission spectra of the mixtures

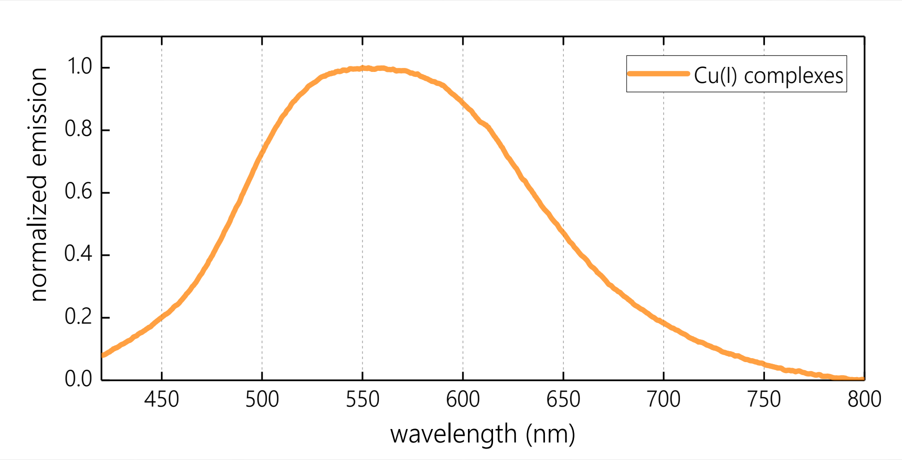
Ir(III) complexes



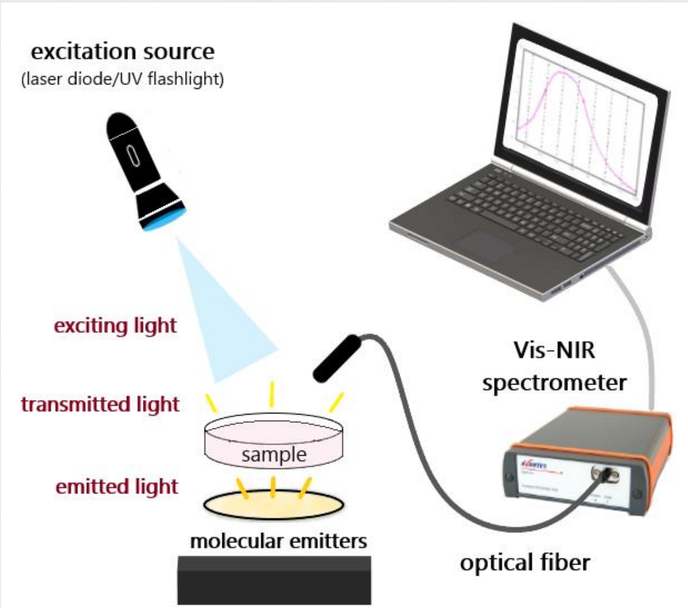


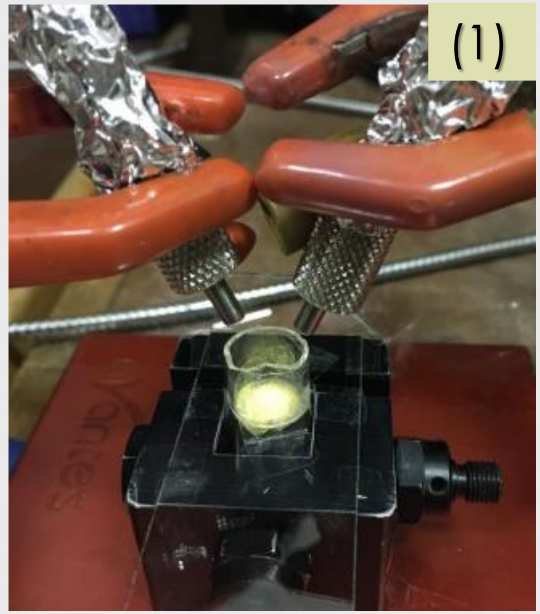
Cu(I) complexes





EXPERIMENTAL





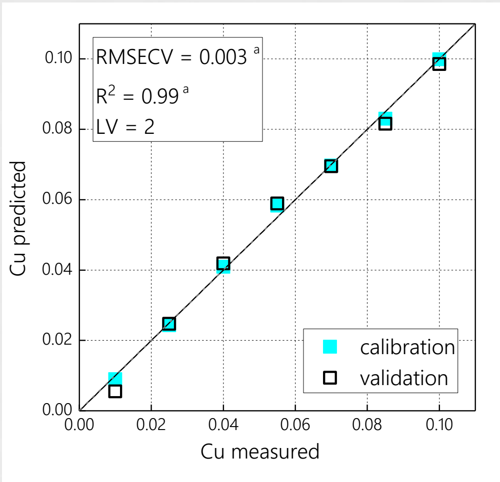
	(1) Ir(III)-based OMS [a]	(2) Cu(I)-based OMS
Sample volume	0.15 mL	4 mL
Sample placement	glass cup (1 cm in diameter)	polystyrene Petri dish (3.5 cm in diameter)
Excitation source	laser diode (λ_{exct} = 365 nm)	laser diode (λ_{exct} = 385 nm) / UV flashlight (λ_{exct} = 365 nm)
Detector	fiber-optic UV–vis spectrometer AvaSpec-ULS2048CL-EVO	

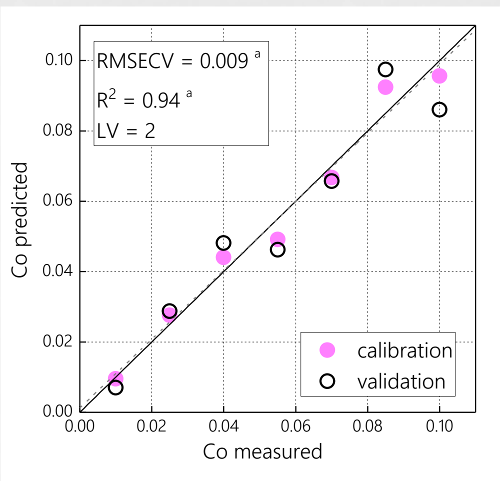
[a] *Gitlina A.Y., Surkova A., Ivonina M.V., et al. Dyes Pigments. 2020; 180:108428. doi: 10.1016/j.dyepig.2020.108428*

RESULTS FOR MODEL SOLUTIONS

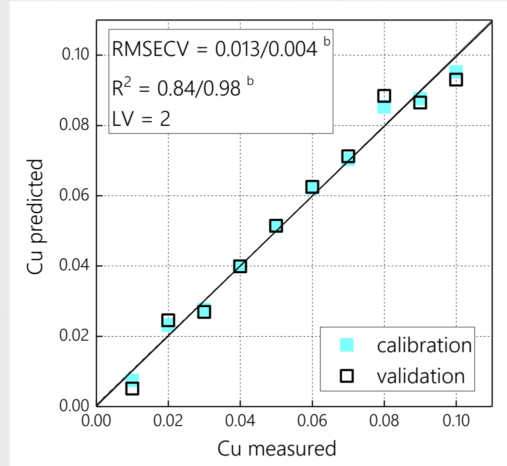
Individual calibration series for Co(II) and Cu(II) nitrates

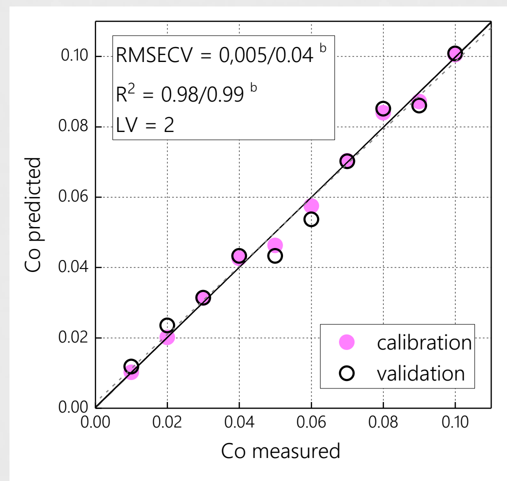
Ir(III)-based OMS

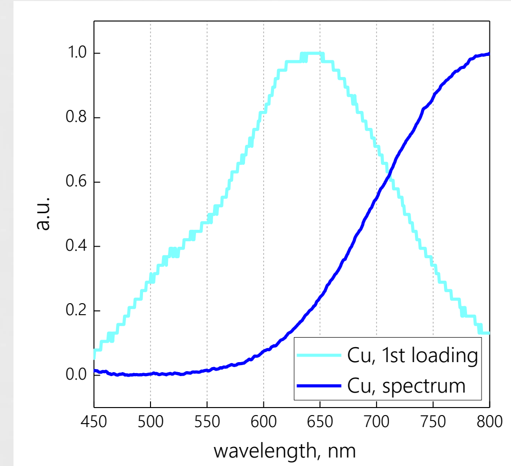


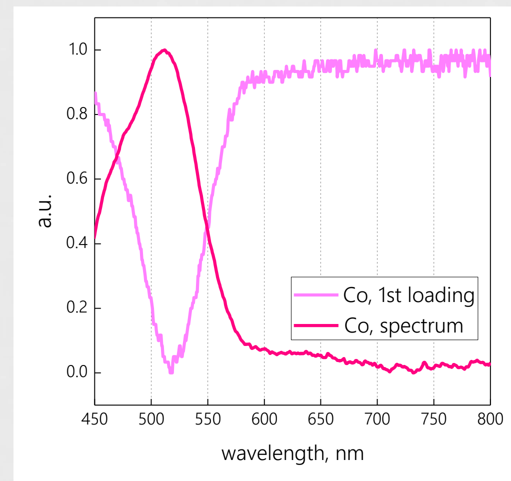


Cu(I)-based OMS







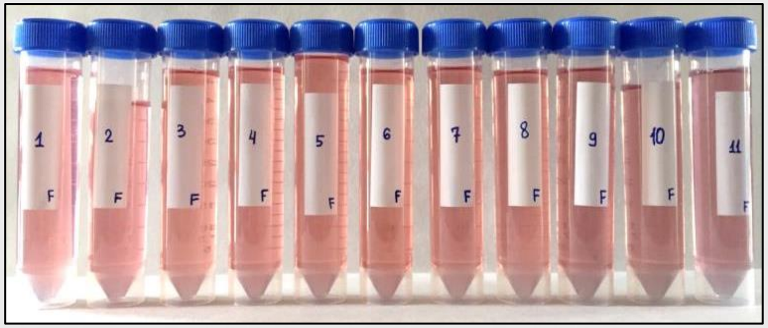


excitation source: [a] laser diode, λ_{exct} = 365 nm; [b] laser diode, λ_{exct} = 385 nm / UV flashlight, λ_{exct} = 365 nm

PRACTICAL APPLICATION

- Calibration sample set for PO_4^{3-}
  - 9 samples
  - 0–0.96 mg/L with 0.12 mg/L step

- Calibration sample set for F^-
  - 11 samples
  - 0–0.4 mg/L with 0.04 mg/L step

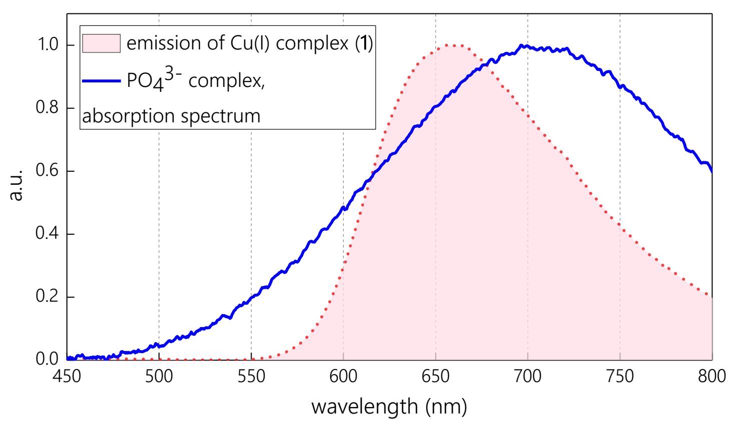


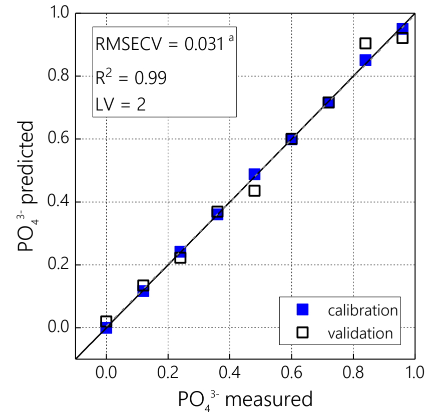
- Test set: 5 samples from tap, rivers (Neva, Volga, Tatyanka) and lake Kaban

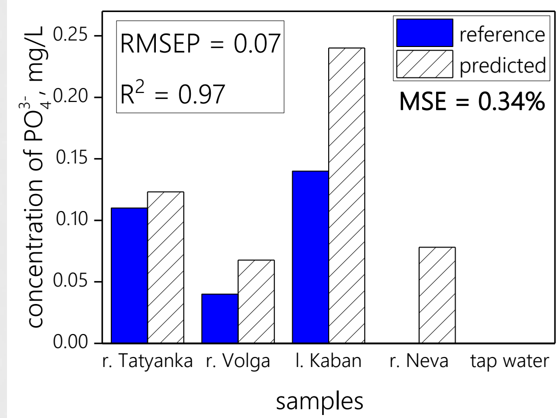
Samples were colored in accordance with the procedures described in GOST 18309-2014 and GOST 4386-89.

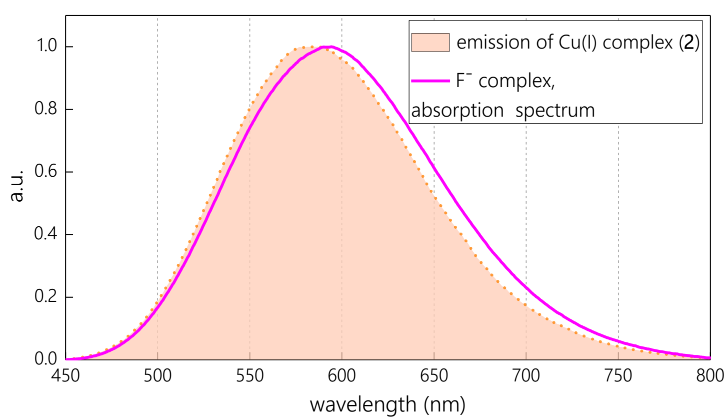
PRACTICAL APPLICATION

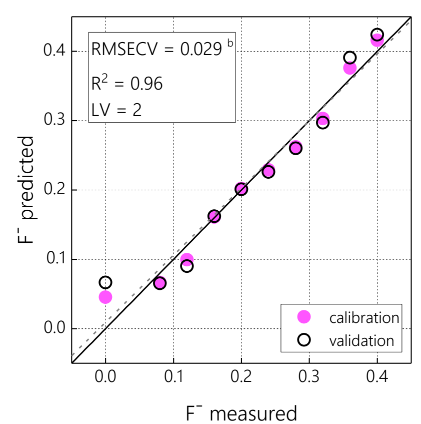
Determination of fluoride and phosphate in surface water

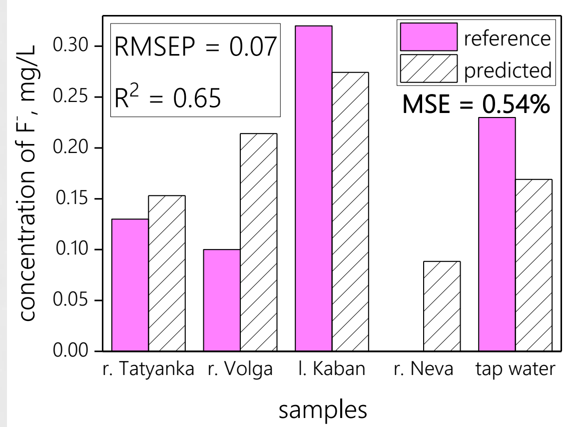












excitation source: UV flashlight (λ_{exct} = 365 nm); interval: [a] 600–750 nm; [b] 450–800 nm

CONCLUSIONS

- Ir(III) and Cu(I)-based complexes are suitable light sources for OMS
- Ir(III) luminescent complexes have bright controlled emission
- Cu(I) complexes are easier to produce, cheaper, and environmentally friendly
- Using UV flashlight instead of laser diode as excitation source is more convenient
- Developed OMS allows determination of fluoride and phosphate in surface waters with high accuracy

ACKNOWLEDGEMENTS

- Saint Petersburg State University
  - PostDoc program
- RSF project #19-79-00076
- Samara State Technical University
- CSAC2021 organizers