# Optical Sensing of Relative Humidity via Azobenzene Photoisomerization

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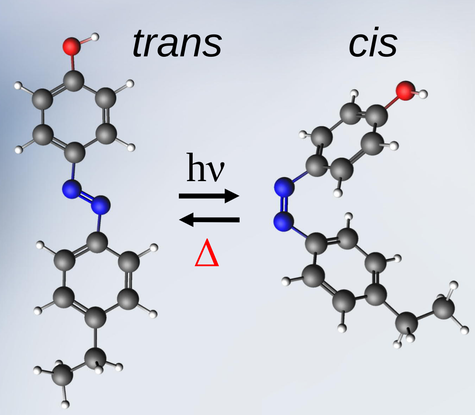
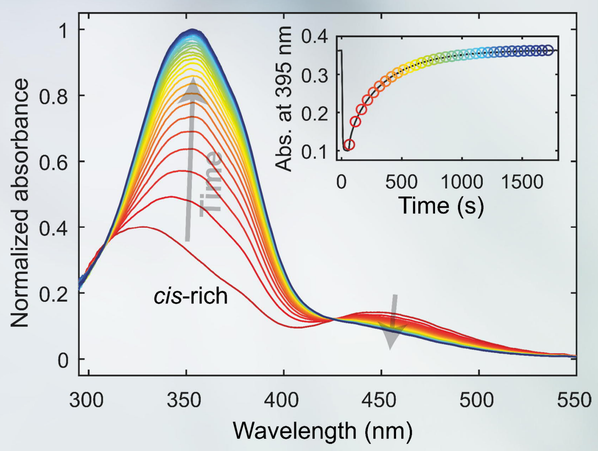
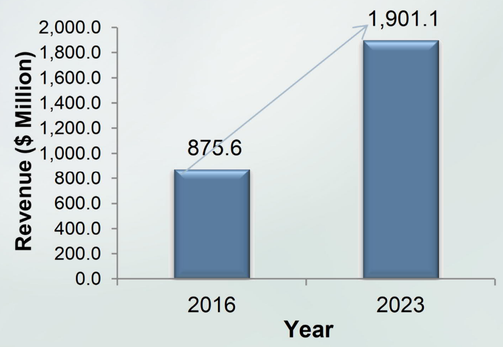
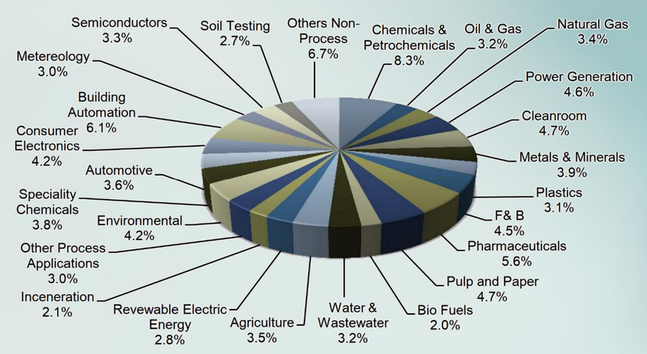
Azobenzenes isomerize with ultraviolet light from *trans* to *cis* and thermally back to *trans*. The *cis*-to-*trans* isomerization rate is strongly affected by substitution of the core azobenzene. Hydroxyazobenzenes show strong dependence of the isomerization rate on their surroundings such as the polarity of their solvent[1]. We show that also in a solid supramolecular polymer with hydroxyazobenes, the rate is strongly dependent on the surroundings, particularly on the ambient relative humidity. Furthermore, thanks to a very systematic change of the rate constant with relative humidity, the material can be turned into a humidity sensor.



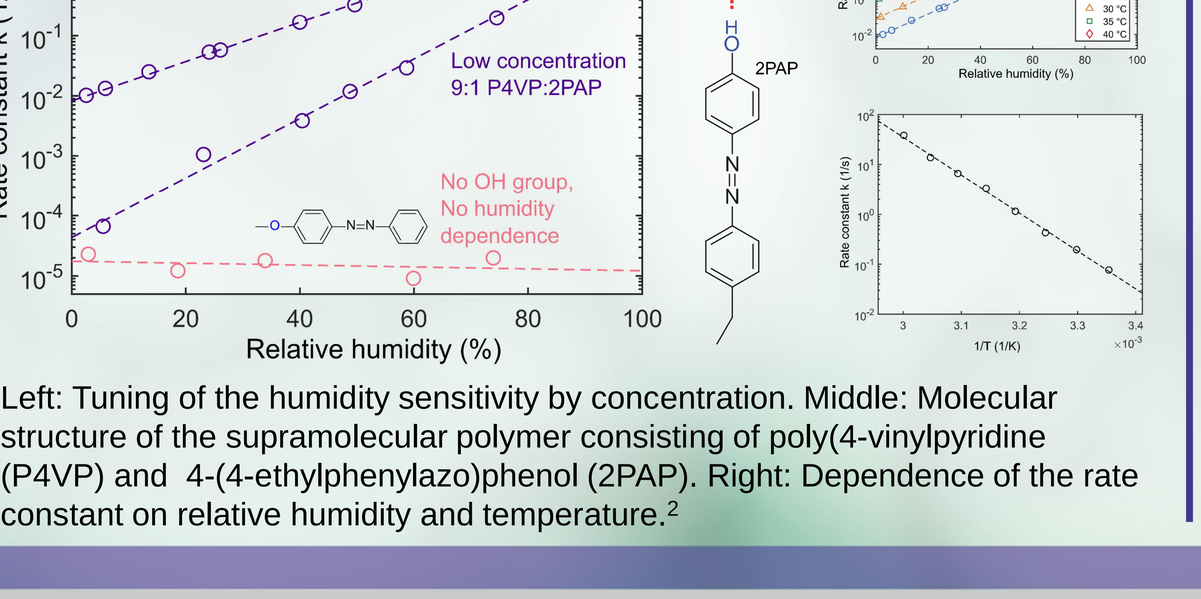




The hydroxyazobenzene isomerizes from *trans* to *cis* with photoexcitation at 360 nm causing a significant change in absorption spectrum. Isomerization from *cis* to *trans* occurs thermally and the original spectrum is fully recovered.[2]

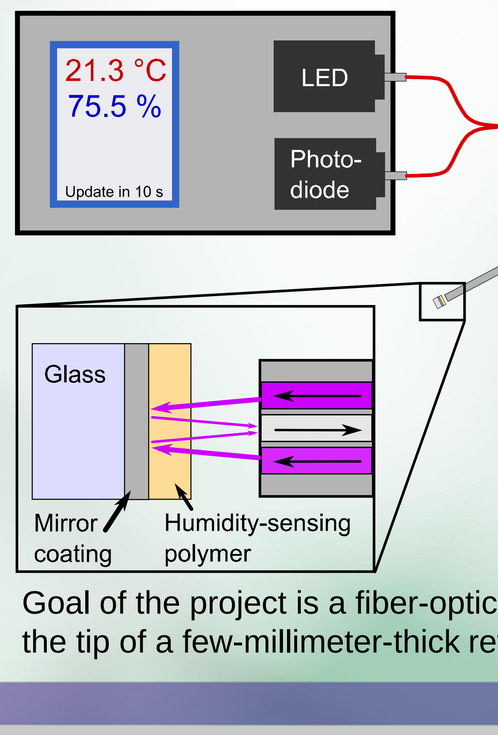



Humidity sensing market is expected to double between 2016 and 2023 while the need for humidity sensing is very scattered.[3]




The proposed mechanism for the sensitivity of the cis-trans isomerization rate of hydroxyazobenzenes to hydrogen-bonding molecules.[2]




1.Measure PD signal without sample (Reference)
2.Measure PD signal without light (Dark reference)
3.Measure dark-adapted absorbance ($A_\infty$)
4.Illuminate for 500 ms,
5.Measure photostationary state absorbance ($A_0$)
6.Measure absorbance periodically: 10 ms, 20 ms, 40 ms, … with <1 ms pulse
7.Fit for k $A(t) = -(A_\infty - A_0)\, e^{-(kt)^\beta} + A_\infty$
8.Measure temperature (T)
9.Solve for relative humidity using calibration data
$k(T, RH) = k_0 e^{-E_a/RT} \cdot e^{\lambda \cdot RH}$

| Salt | Equilibrium RH, 20 °C | RH temperature stability |
|---|---|---|
| LiCl | 11.30 % | 11.29 %, 10 °C 11.28 %, 30 °C |
| $K_2CO_3$ | 43.16 % | 43.14 %, 10 °C 43.17 %, 30 °C |
| NaCl | 75.47 % | 75.67 %, 10 °C 75.09 %, 30 °C |

Current prototype humidity measuring device and the operation principle. Microcontroller allows standalone operation and the footprint is 30 x 40 cm.




Left: Tuning of the humidity sensitivity by concentration. Middle: Molecular structure of the supramolecular polymer consisting of poly(4-vinylpyridine (P4VP) and 4-(4-ethylphenylazo)phenol (2PAP). Right: Dependence of the rate constant on relative humidity and temperature.[2]




Goal of the project is a fiber-optic device that allows humidity measurement in the tip of a few-millimeter-thick reflection probe.

**REFERENCES**

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