Photocatalysis as a way to fight against microbial growth?

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- Microorganisms main substrates: **indoor surfaces** [Raw et al., 1999b]

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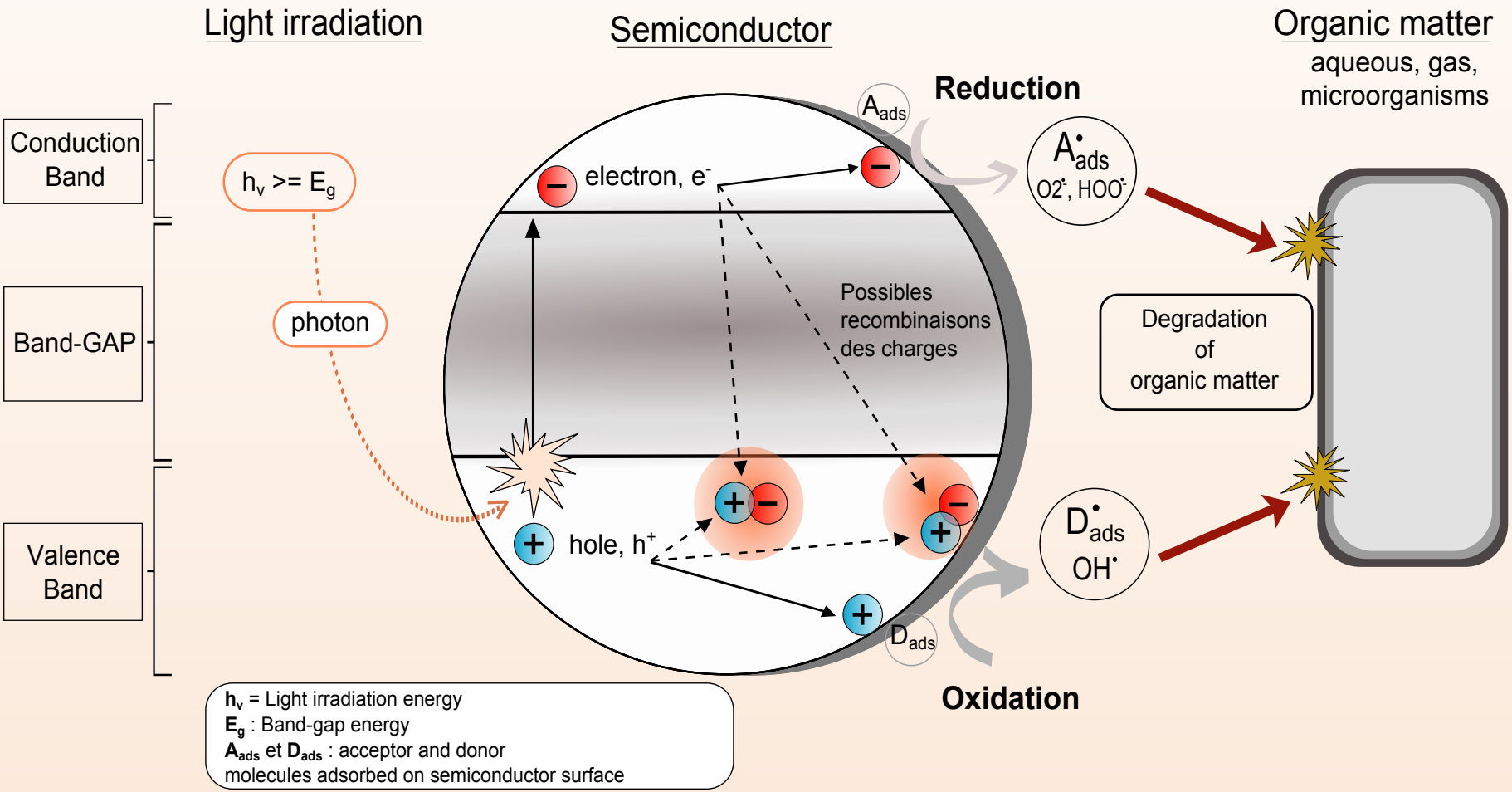
AIM: To develop photocatalytic building materials that are active under visible light and effective against microbial growth inside buildings

The principle of Photocatalysis



Efficiency of TiO_2 under UV light irradiation

- Bacteria inactivation rates:
  - 3log (99,9%) after 30 min ($\approx 40°C$) *E. coli*, TiO_2 powder (1 g/L)
    [Wei et al., 1994]
  - 6log (99,9999%) after 90 min, drop of *E. coli*, TiO_2 thin film
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- High efficiency after short times on *E. coli* **in water or in aqueous phase**
- Slower inactivation kinetics on fungi
- Studies usually focused on *E. coli*, few on fungi

Procedures

1. Photocatalytic materials
2. Microbial strains
3. Methods
4. Experimental conditions

Photocatalytic materials

Normal products activable by **UV irradiation**

- Nanoparticles of TiO_2, KronoClean7000
- Ultralight varnish-type coatings, specifically formulated

Doped products activable by **visible light**

- Nanoparticles of TiO_2, KronoClean7050
- Ultralight varnish-type coatings, specifically formulated

Collaboration with **LRVision** (Toulouse SME)

Microbial strains: Standards / inside buildings

Bacteria

- *E. coli*, vegetative form
- *B. pumilus*, spores

Fungi

- *Cladosporium* sp.
- *Penicilium* sp.
- *Aspergillus* sp.

Methods - Based on microbiology standards

2 types of experiments:

Microbicide effect

- Standards:
  - JIS Z 2801
  - ISO 27447
- 4-step experiments:
  1. Growth
  2. Incubation
  3. Wash-out
  4. CFU counting

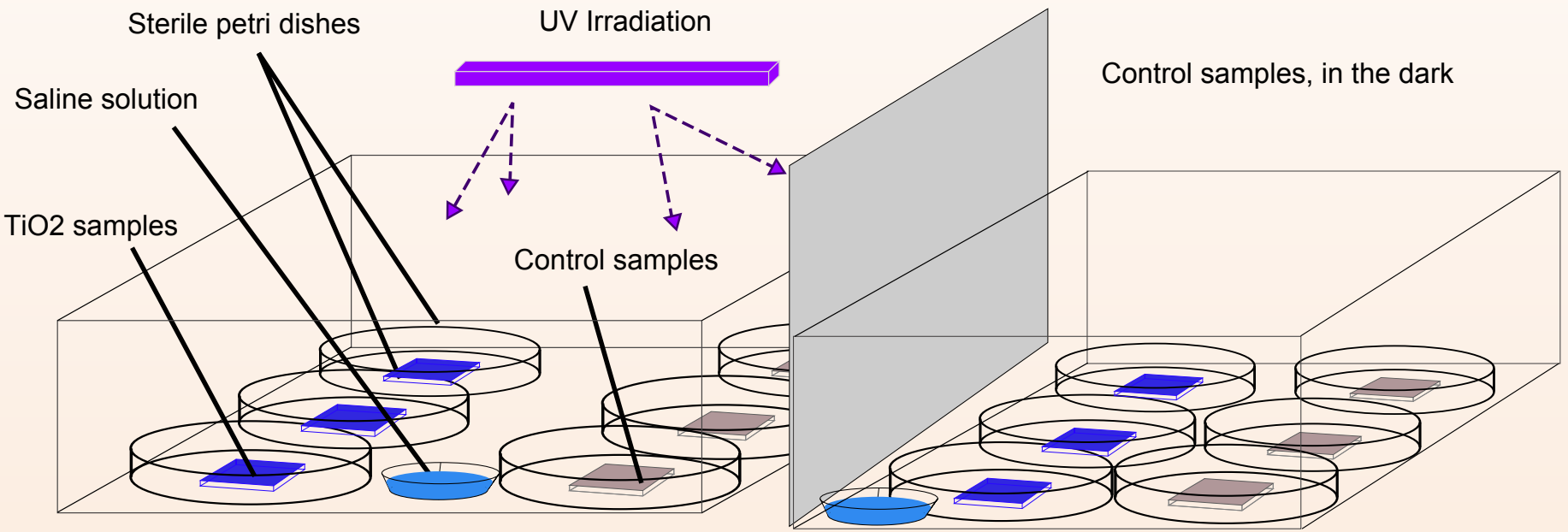
Growth inhibition

- Standards:
  - ASTM C 1338, ASTM D 3273
  - NF EN ISO 846
- 3-step experiments:
  1. Growth
  2. Incubation
  3. Observations on materials

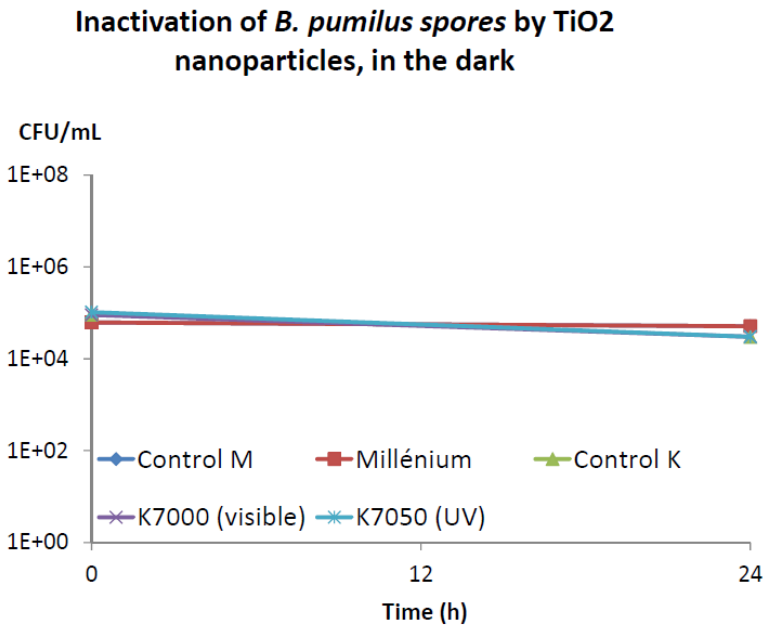
Experimental conditions

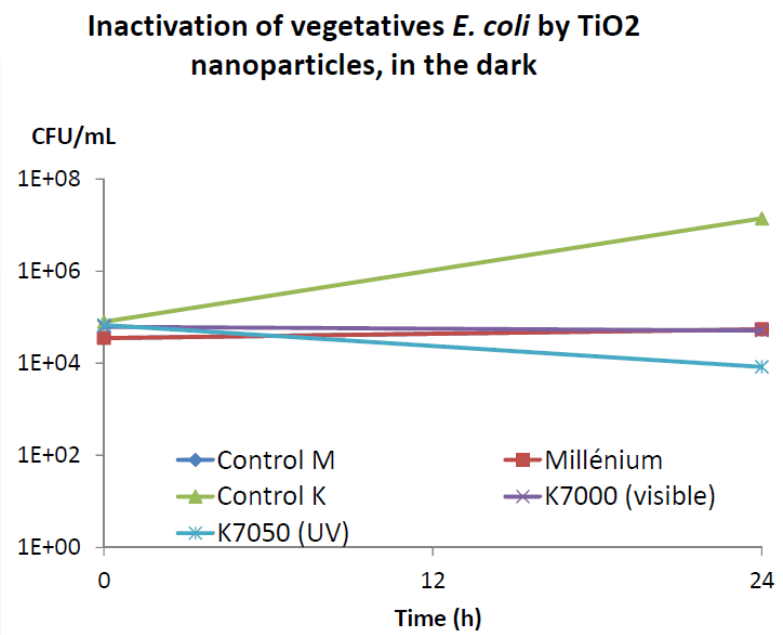
- **Light irradiation**:
  - UV (388 nm)
  - Visible light (400 - 700 nm)
- **Humidity** and **Temperature**:
  - To promote microbial growth
  - Found inside buildings
- **Contact** between materials/microorganisms/water:
  - Normal
  - Forced (with a transparent film)

Schematic illustration



TiO2 kept in the dark, 25°C

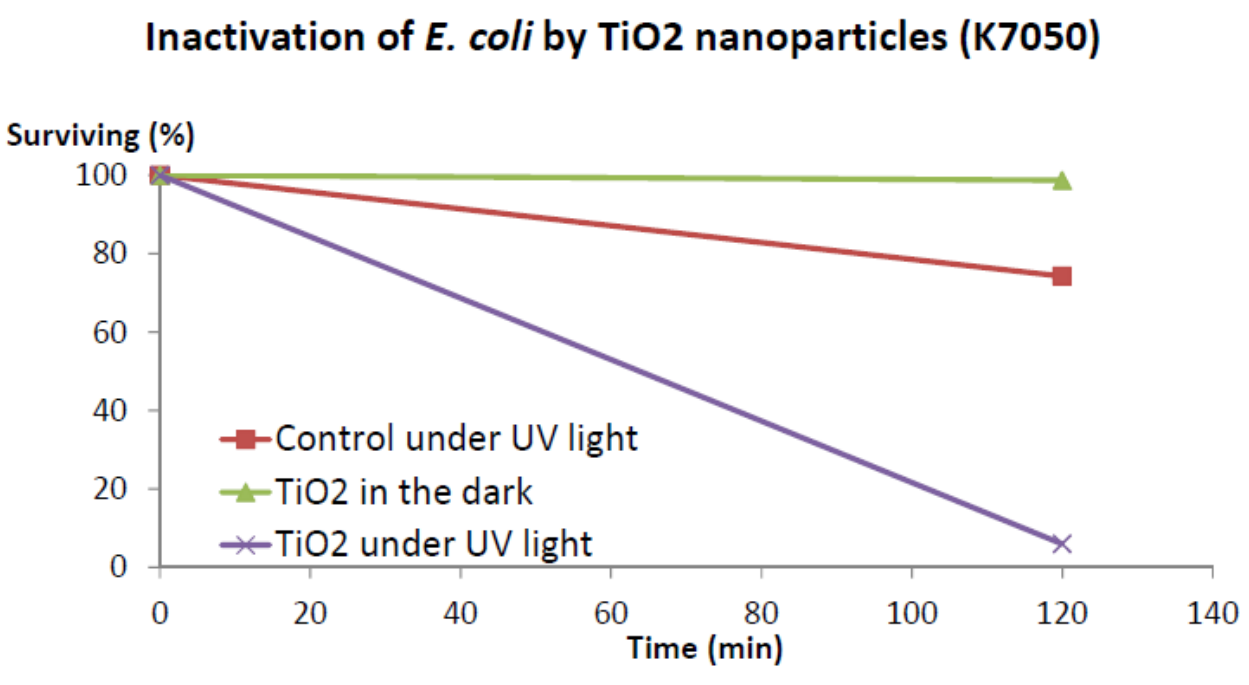




- No significant evolution
- Resistance of spores

- Antibacterial activity :
  - PC500: $2,2\log(99,29\%)$
  - K7000: $2,4\log(99,63\%)$
  - K7050: $3,2\log(99,94\%)$

TiO_2 K7050 illuminated (UV), 25°C, contact forced



- Bactericidal effect:
  - 1, 23 log after 120 min of irradiation

Conclusions - Discussions

- Effect significant after 24h without light irradiation
  - Probably due to a phagocytosis phenomen of TiO2 larger aggregates [Cai et al., 1991]
- No effect with UV irradiation when inoculum is not covered by a film (data not shown)
- Effect significant after 120 min under UV irradiation with a forced contact
- Importance of:
  1. The contact between bacteria and nanoparticles
  2. The aqueous phase

  } For the inactivation of bacteria

Short and long-term outlooks

1. Efficiency of materials

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   - Work still in progress:
     - Role of the water in the reaction
     - Antimicrobial activity of ultralight varnishes (semi-transparent coating) formulated using TiO_2 nanoparticles under UV / visible light

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     - Biobased products intended for cimentitious materials
2. Environmental and health impact:
   - Emission of mVOC
   - Development of eco(geno)toxicity tests for varnishes and TiO_2 nanoparticles (on *Xenopus Laevis* larvae)
   - Evaluation of the possible toxicity of the formulated coatings (VOC analysis)

Thank you for your attention

any questions ?

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