



UNIVERSITÀ
DEGLI STUDI
DI MILANO



SISTEMI FOTOCATALITICI PER LA DECONTAMINAZIONE MICROBICA



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Campo principale di ricerca

- Studio della biogenesi dell'involucro dei batteri Gram-negativi
- Identificazione e validazione di bersagli molecolari per lo sviluppo di nuovi antibiotici convenzionali e "non-convenzionali"
- Messa a punto di screenings per l'identificazione di molecole bioattive

Enti Finanziatori

Fondazione per la ricerca della Fibrosi Cistica

Regione Lombardia

Fondazione Cariplo

Ministero Università e Ricerca

Fondazione Comunità di Milano (11/2020 – 11/2021)

Comunità Europea (MSCA-ITN 2017-2020; MSCA-DN 2023-2026)

Attività di ricerca commissionata

- Valutazione delle proprietà antibatteriche e antiadesione di materiali variamente funzionalizzati

Attività di ricerca svolta dalla Dott.ssa FLAVIA DI VINCENZO



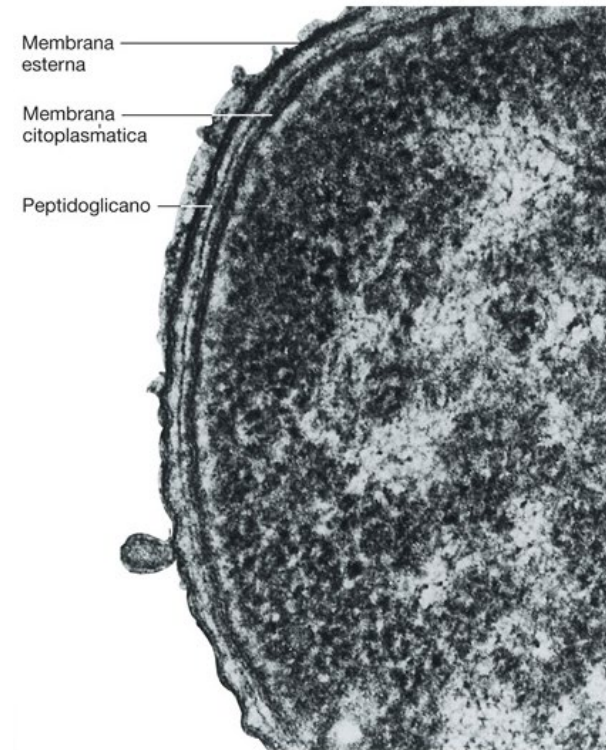
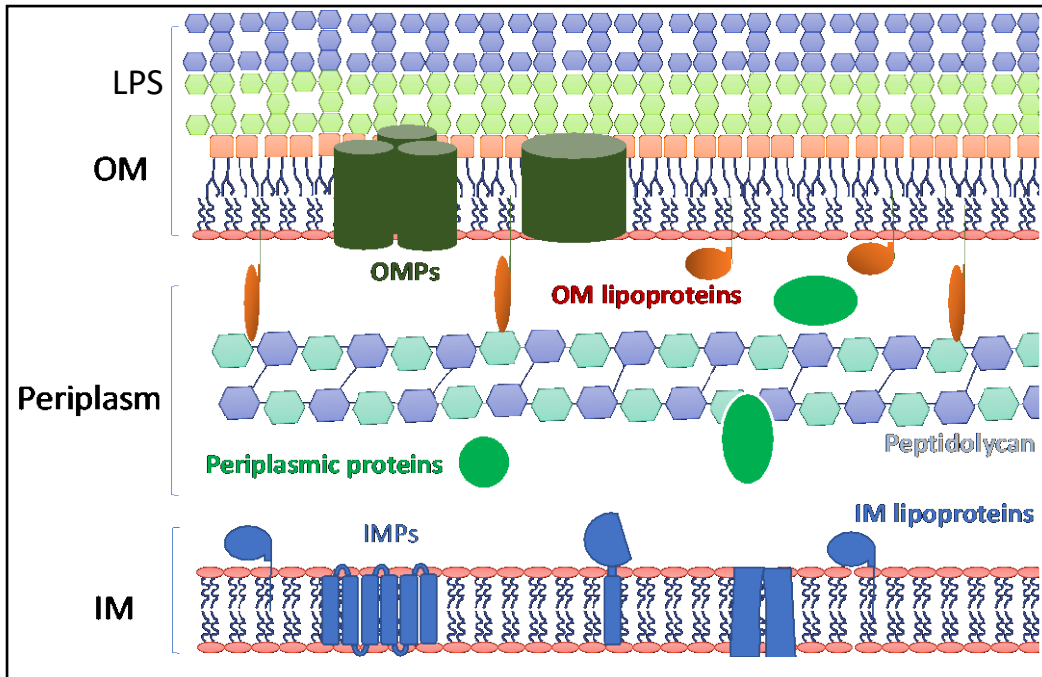
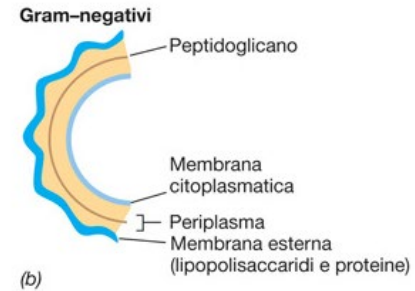
Novembre 2020 - Novembre 2021

Borsa per giovani promettenti finanziata dal Fondo
Bellobono-Stefanelli

Valutazione dell'attività antimicrobica di fotocatalizzatori a
base di TiO_2/WO_3

➤ *Escherichia coli*: Gram-negative model organism, multi-layered cell envelope

- non-pathogenic symbiotic strains
- pathogenic strains responsible of several outbreaks



Escherichia coli photoinactivation

ISO 27447:2019

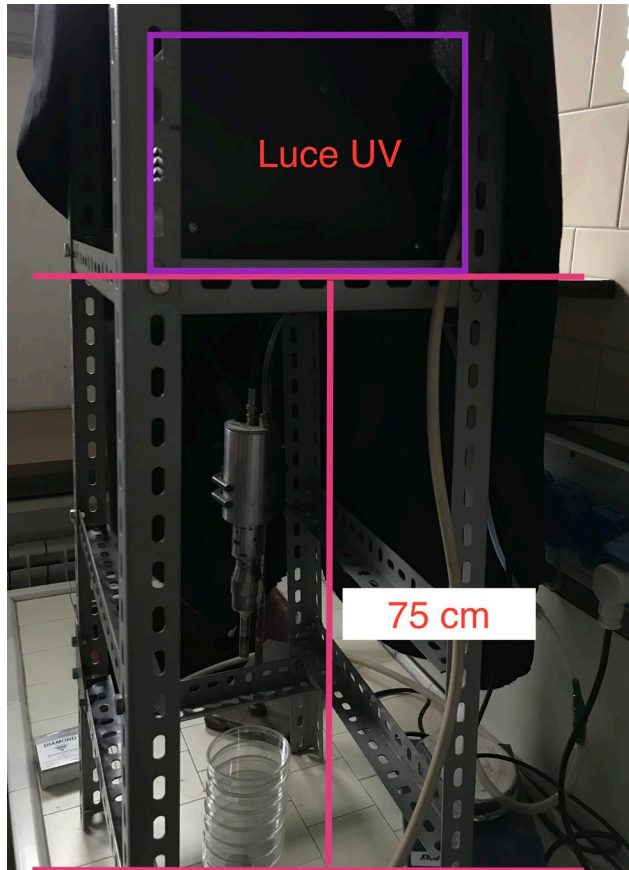
Fine ceramics (advanced ceramics, advanced technical ceramics)
Test method for antibacterial activity of semiconducting photocatalytic materials

Sterile petri dishes coated with photocatalytic films

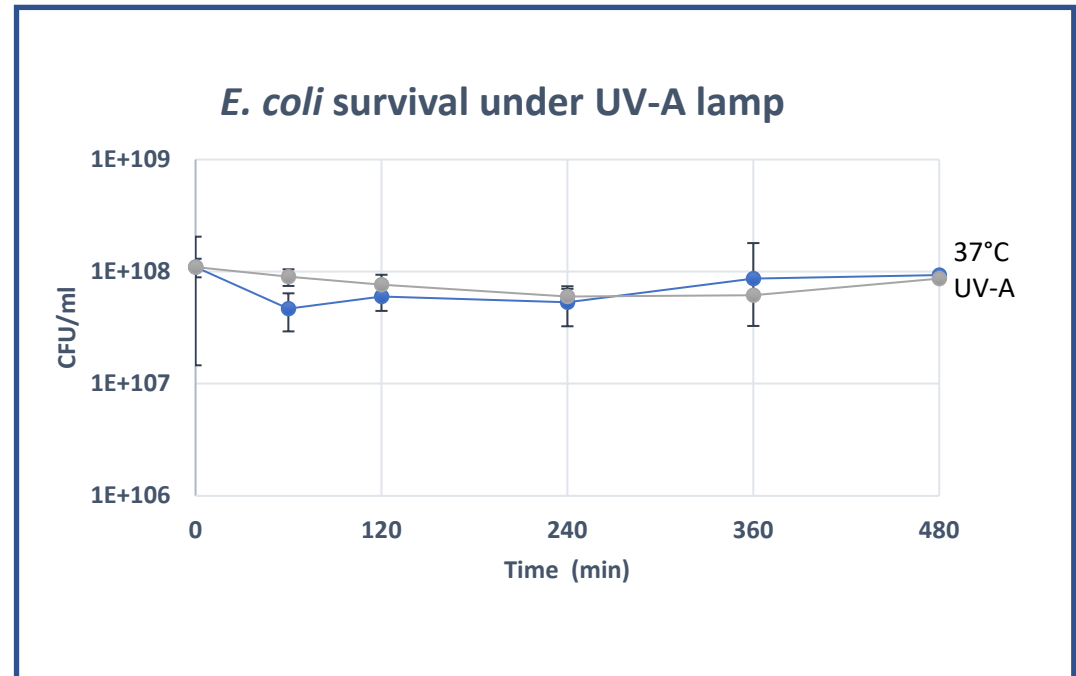
Photocatalysis under UV-A irradiation
Photocatalysis under visible light irradiation

Antibacterial activity: microbial reduction $\geq 90\%$

Escherichia coli photoinactivation



UV-A lamp power 2.5 Watt/m²



TiO₂/WO₃ composites analysed

1. JA-1 TiO₂ (180 nm size) composites calcined at 600°C
2. AMT100 TiO₂ (6 nm size) composites calcined at 600°C
3. AMT600 TiO₂ (30 nm size) composites calcined at 400°C
4. AMT100 TiO₂ (6 nm size) composites calcined at 400°C

Synthesis and characterization: Prof. Claudia Bianchi laboratory

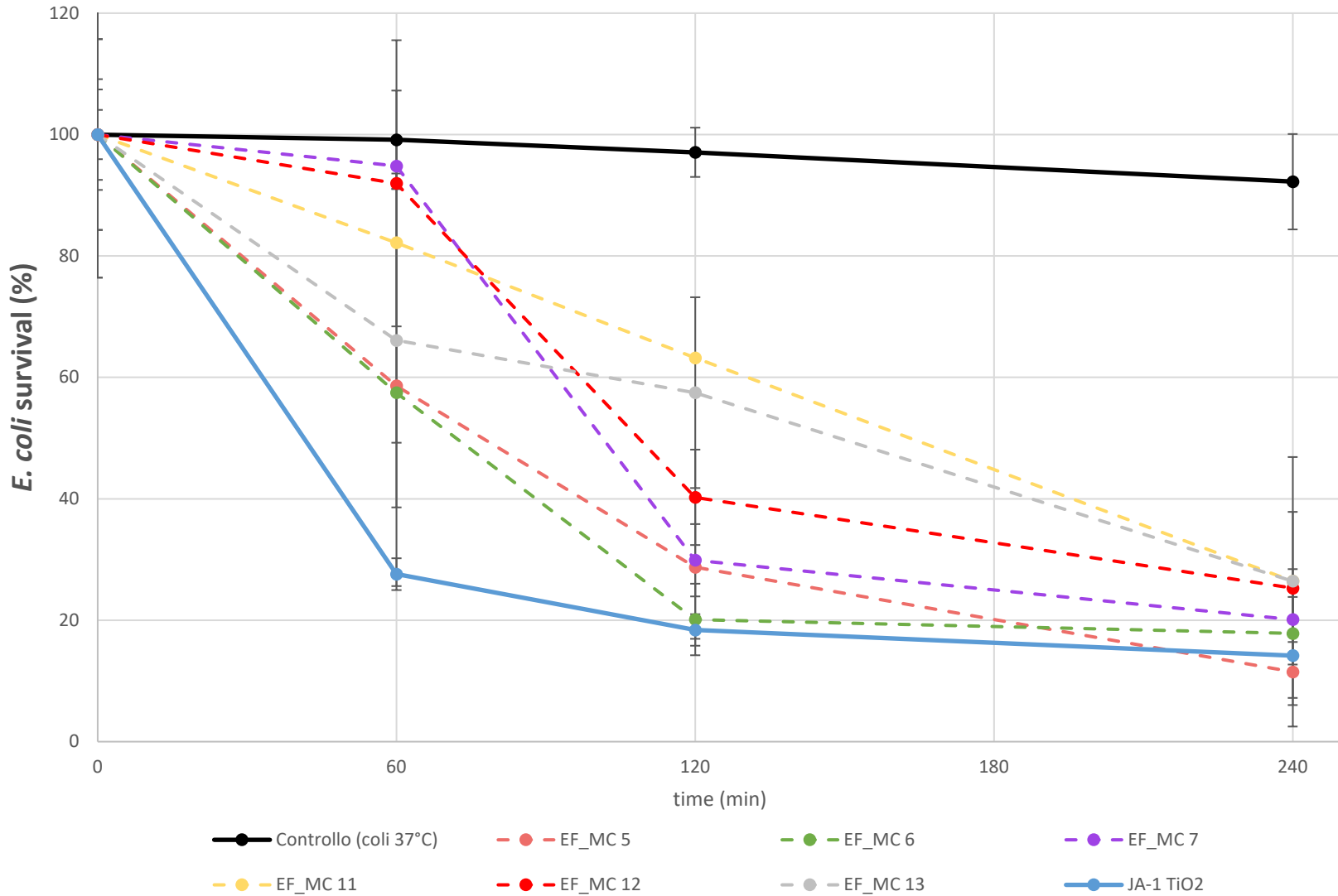
1. JA-1 TiO₂ composites calcined at 600°C

| Nome campione | Tipo di titania | WO ₃ w/w % | TiO ₂ w/w % | Agitazione | Base | Quantità |
|---------------|-----------------|-----------------------|------------------------|------------|--------------------------|----------|
| EF_MC5 | JA-1 | 20% | 80% | Magnetica | NaOH, NH ₄ OH | 1,7630 g |
| EF_MC6 | JA-1 | 20% | 80% | Ultrasuoni | NaOH, NH ₄ OH | 1,9191 g |
| EF_MC7 | JA-1 | 50% | 50% | Magnetica | NaOH, NH ₄ OH | 1,8532 g |
| EF_MC11 | JA-1 | 50% | 50% | Magnetica | NH ₄ OH | 1,9009 g |
| EF_MC12 | JA-1 | 50% | 50% | Ultrasuoni | NaOH, NH ₄ OH | 1,9981 g |
| EF_MC13 | JA-1 | 50% | 50% | Ultrasuoni | NH ₄ OH | 1,9764 g |

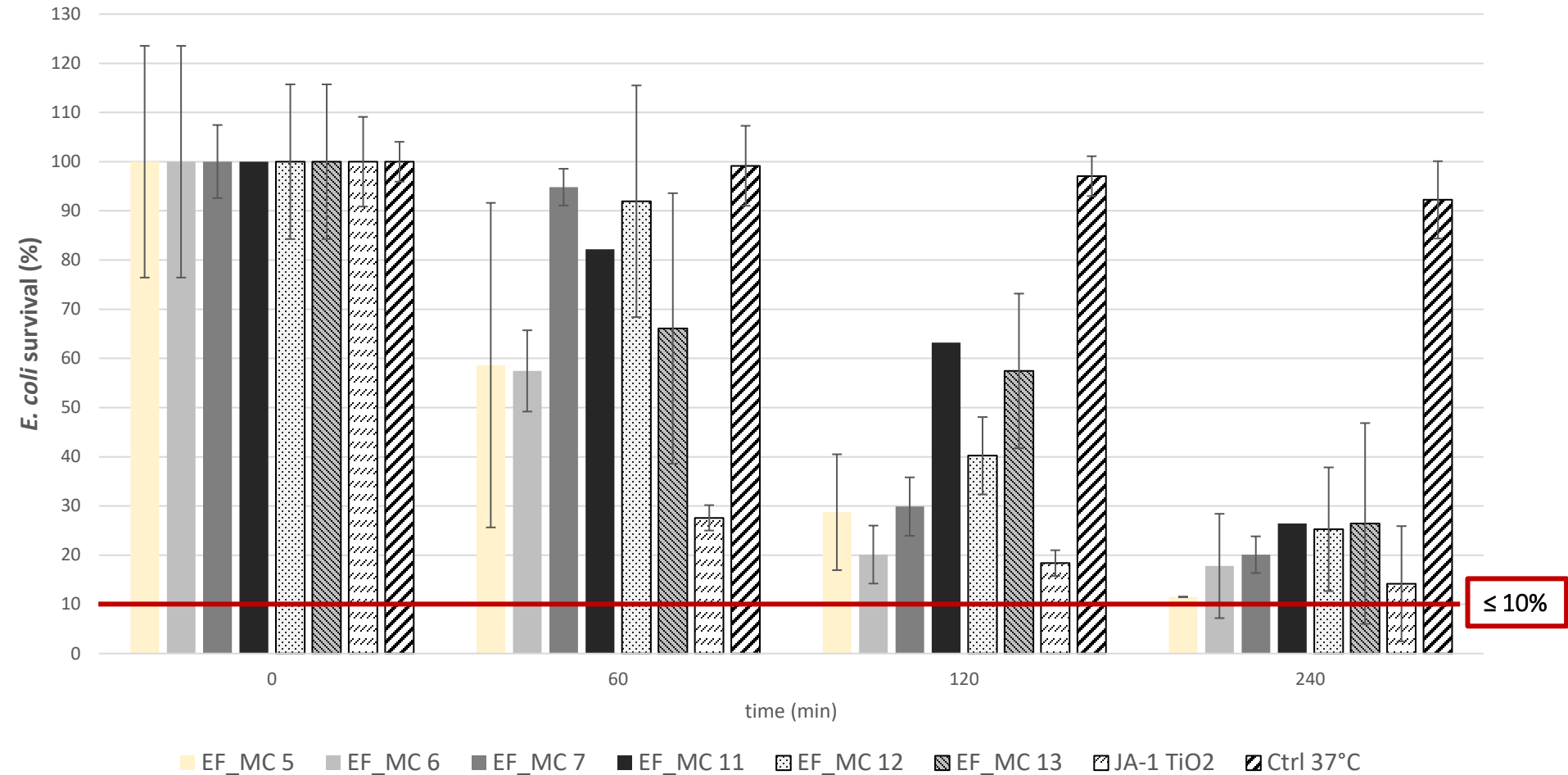


JA-1 size = 180 nm

1. *E. coli* survival (%) JA-1 TiO₂ composites calcined at 600°C



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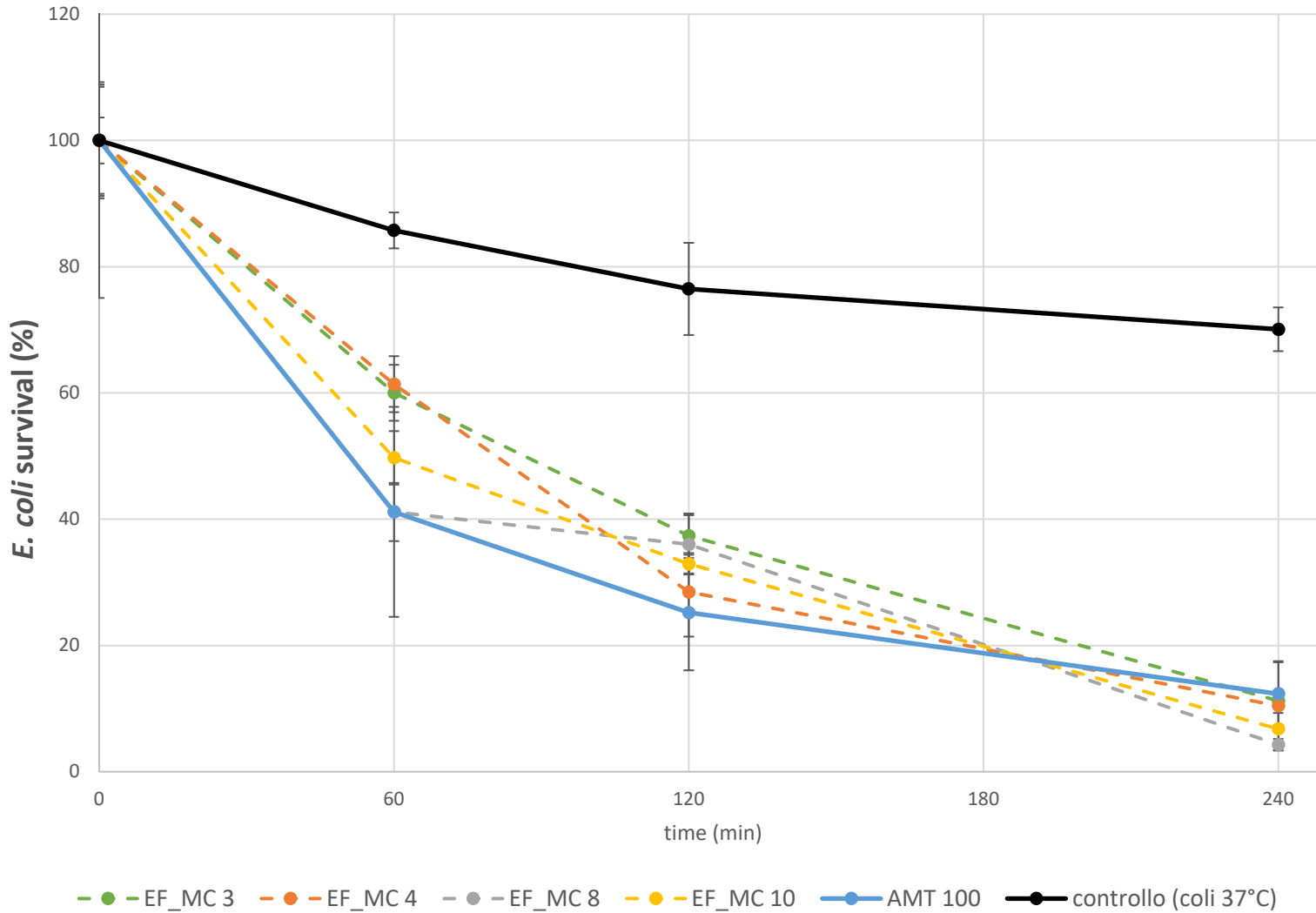
2. AMT100 TiO₂ composites calcined at 600°C

| Nome campione | Tipo di titania | WO ₃ w/w % | TiO ₂ w/w % | Agitazione | Base | Quantità |
|---------------|-----------------|-----------------------|------------------------|------------|--------------------------|----------|
| EF_MC3 | AMT 100 | 20% | 80% | Ultrasuoni | NaOH, NH ₄ OH | 1,7148 g |
| EF_MC4 | AMT 100 | 20% | 80% | Magnetica | NaOH, NH ₄ OH | 1,8428 g |
| EF_MC8 | AMT 100 | 50% | 50% | Ultrasuoni | NaOH, NH ₄ OH | 1,9374 g |
| EF_MC10 | AMT 100 | 50% | 50% | Magnetica | NaOH, NH ₄ OH | 1,7769 g |

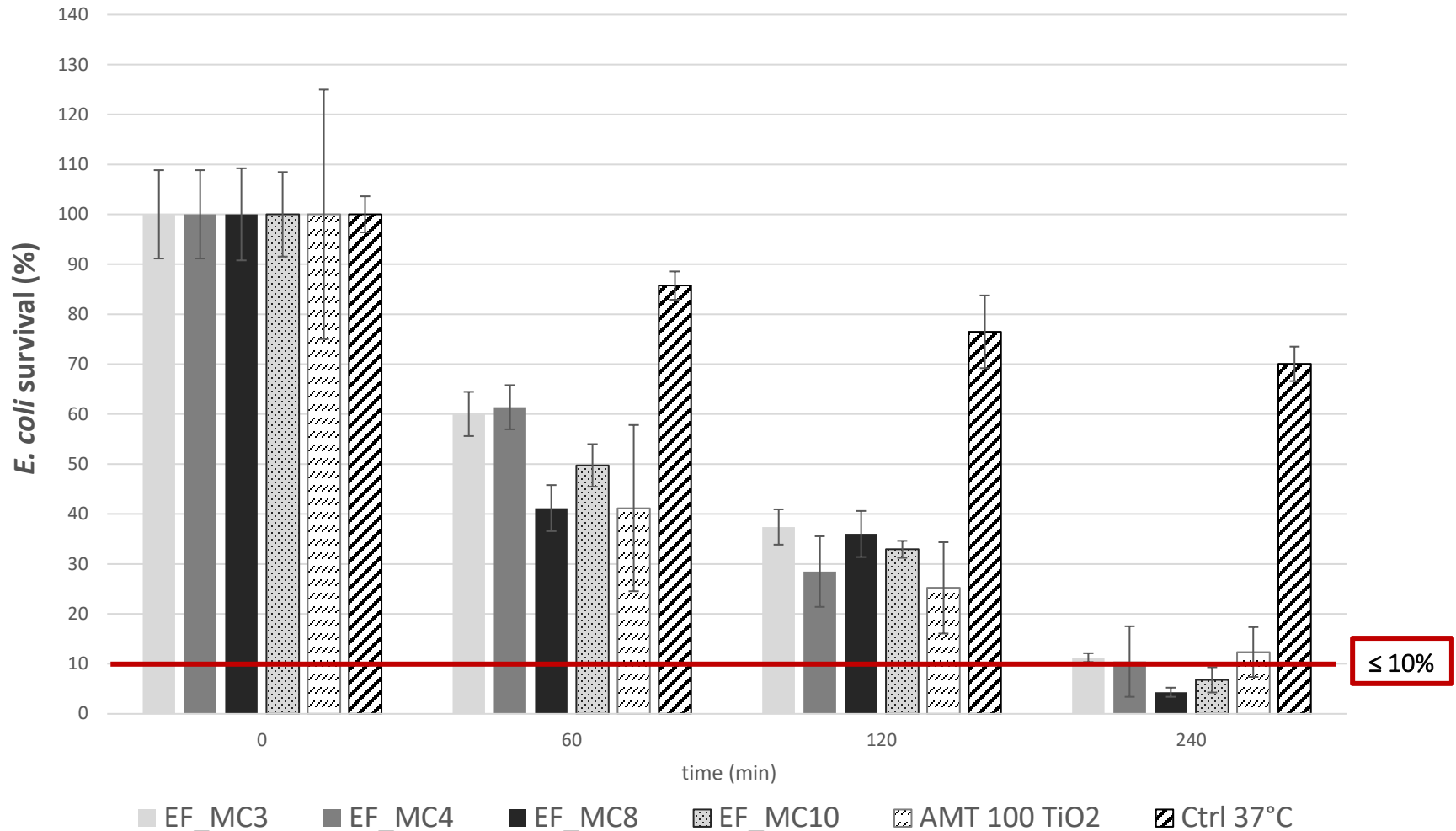


AMT100 size = 6 nm

2. *E. coli* survival (%) AMT100 TiO₂ composites calcined at 600°C



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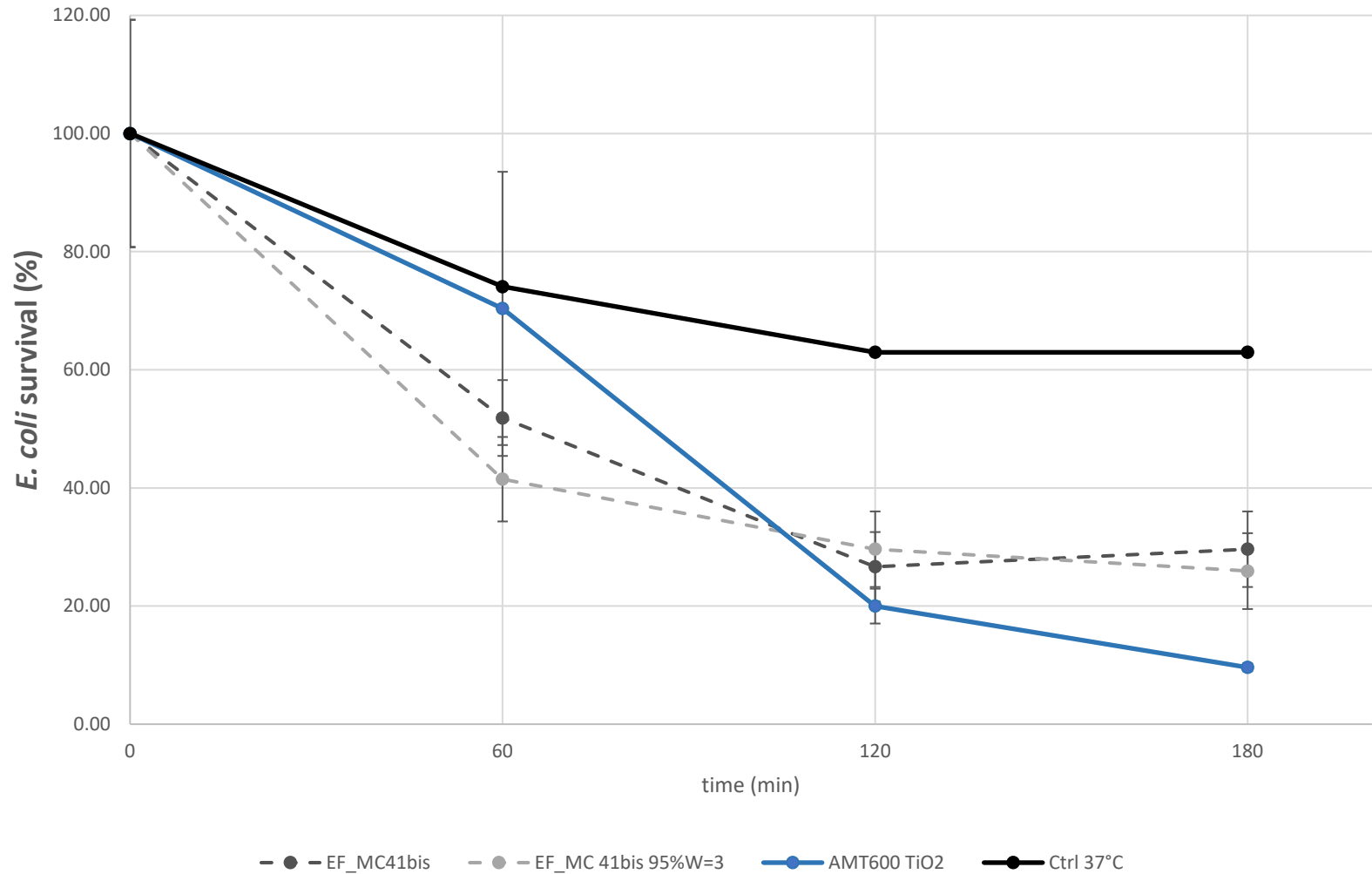
3. Samples with AMT600 TiO₂ calcined at 400°C

| Nome campione | Tipo di titania | WO₃ w/w % | TiO₂ w/w % | Agitazione |
|----------------------|------------------------|-----------------------------|------------------------------|-------------------|
| EF_MC41bis | AMT 600 | 90% | 10% | Miscela meccanica |
| EF_MC41@95%WO3 | AMT 600 | 95% | 5% | Miscela meccanica |

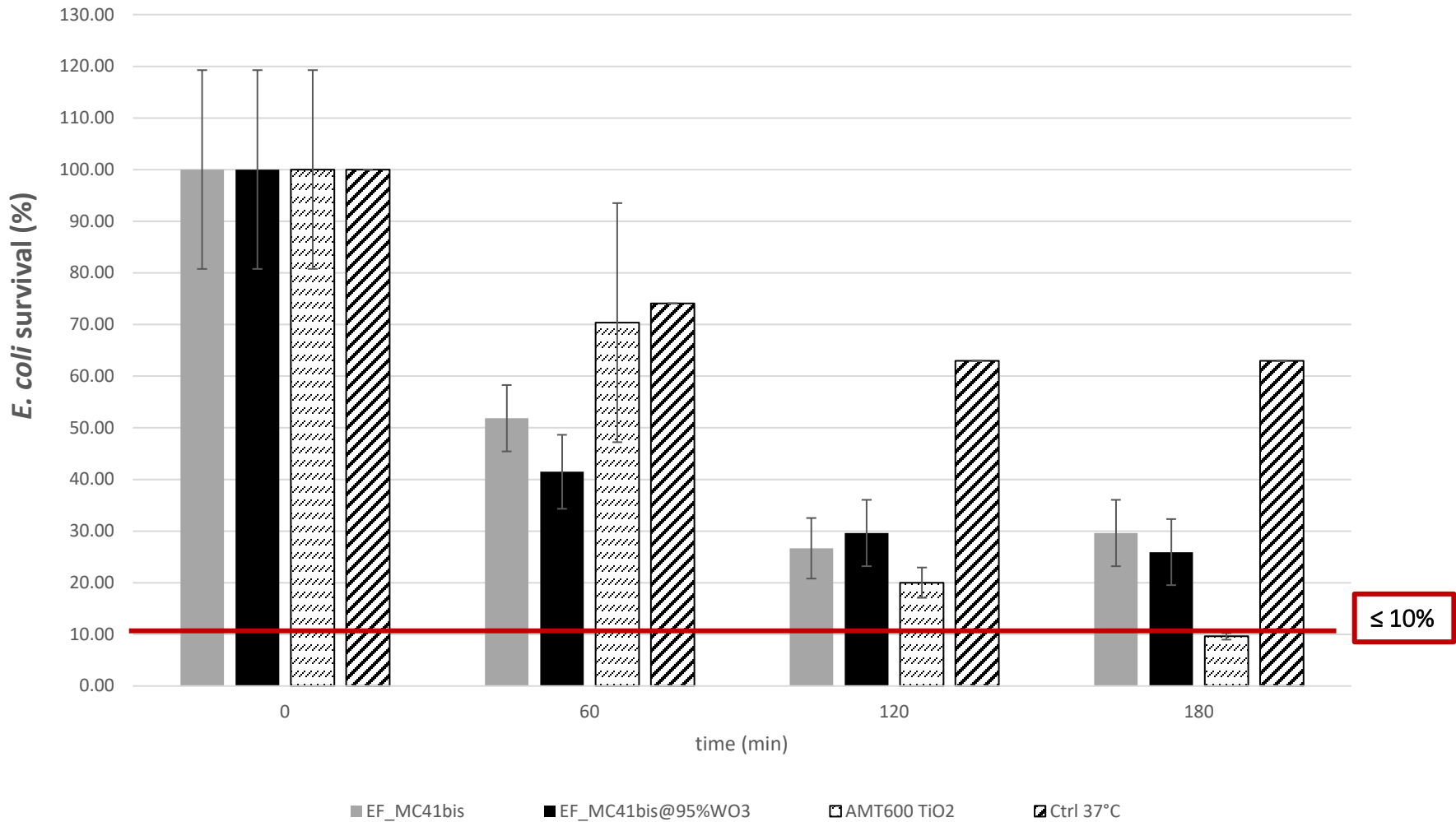
AMT600 size = 30 nm



3. *E. coli* survival (%) AMT600 TiO₂ composites calcined at 400°C



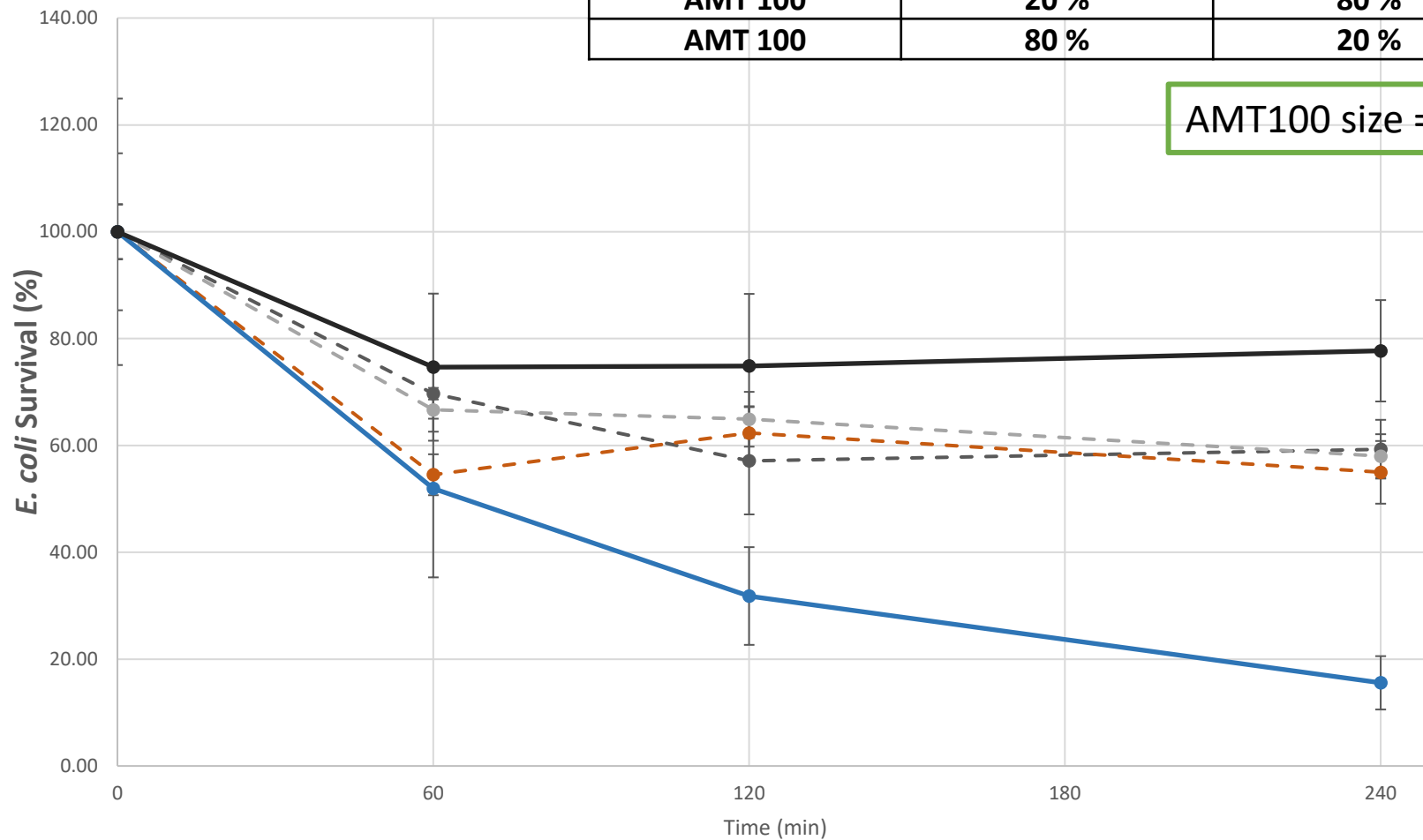
3. *E. coli* survival (%) AMT600 TiO₂ composites calcined at 400°C



4. *E. coli* survival (%) AMT100 TiO₂ composites calcined at 400°C

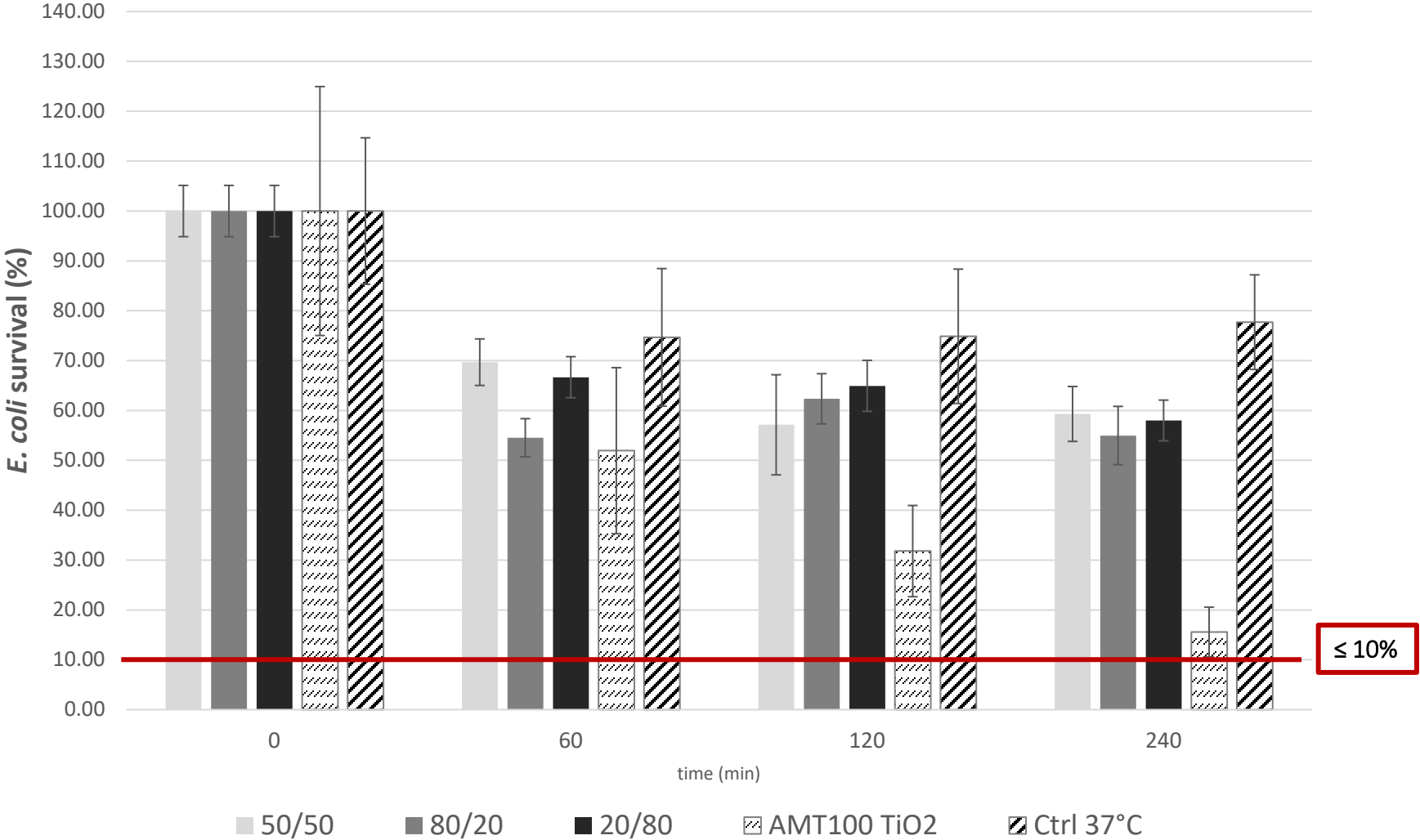
| Tipo di titania | WO ₃ w/w % | TiO ₂ w/w % |
|-----------------|-----------------------|------------------------|
| AMT 100 | 50 % | 50 % |
| AMT 100 | 20 % | 80 % |
| AMT 100 | 80 % | 20 % |

AMT100 size = 6 nm



—●— 50/50 —●— 80/20 —●— 20/80 —●— AMT100 TiO₂ —●— Ctrl 37°C

4. *E. coli* survival (%) AMT100 TiO₂ composites calcined at 400°C



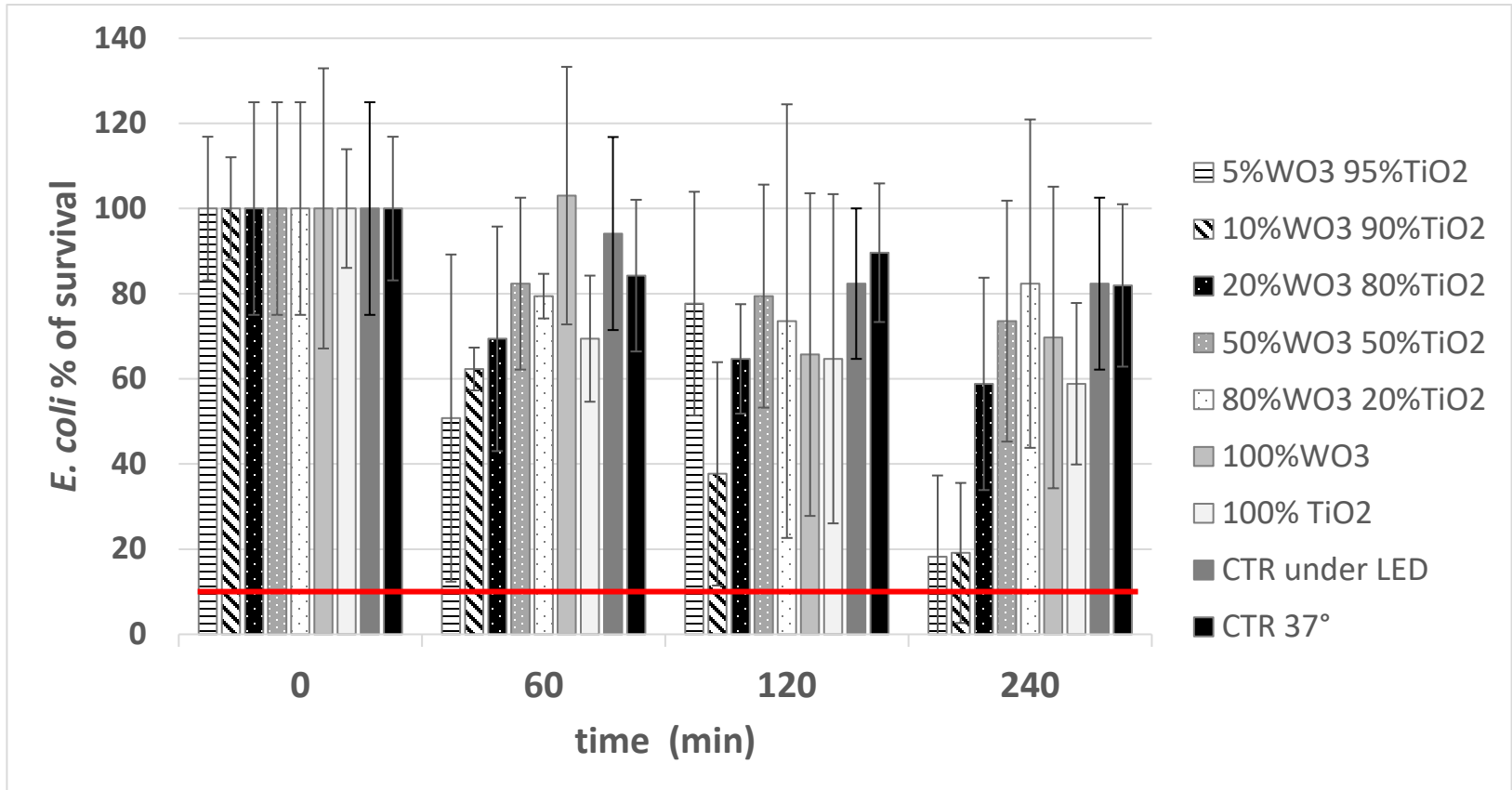
E. coli photoinactivation under visible light irradiation

Doping TiO₂ with WO₃ can extend the wavelength spectrum of radiation absorption, so that also visible light can be used to trigger photocatalysis?

| Sample | WO ₃ /TiO ₂ (w/w ratio) | Calcination temperature (°C) | Yield (%) |
|---------------------------------------|---|------------------------------|-----------|
| WO ₃ | 100:0 | 400 | 95.2 |
| WO ₃ @TiO ₂ _80 | 80:20 | 400 | 95.7 |
| WO ₃ @TiO ₂ _50 | 50:50 | 400 | 95.1 |
| WO ₃ @TiO ₂ _20 | 20:80 | 400 | 94.8 |
| WO ₃ @TiO ₂ _10 | 10:90 | 400 | 96.2 |
| WO ₃ @TiO ₂ _5 | 5:95 | 400 | 95.7 |
| TiO ₂ | 0:100 | 400 | 98.5 |

LED lamp - 2900 lux

E. coli survival (%) AMT100 TiO₂ composites calcined at 400°C



CONCLUSIONS

- TiO_2 size seem to matter for antibacterial activity
- High concentration of WO_3 seem to have a negative impact on antibacterial activity
- Doping TiO_2 with WO_3 cannot extend the wavelength spectrum of radiation absorption, to trigger photocatalysis under visible light

