Light-activated 'TROJAN' surfactants for fast anti-microbial/viral action

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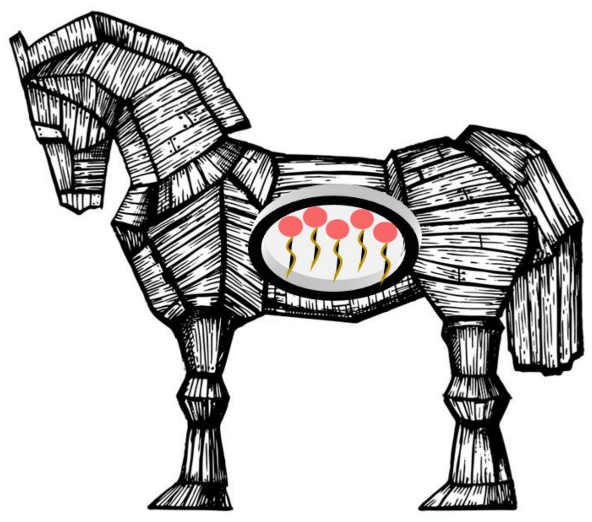
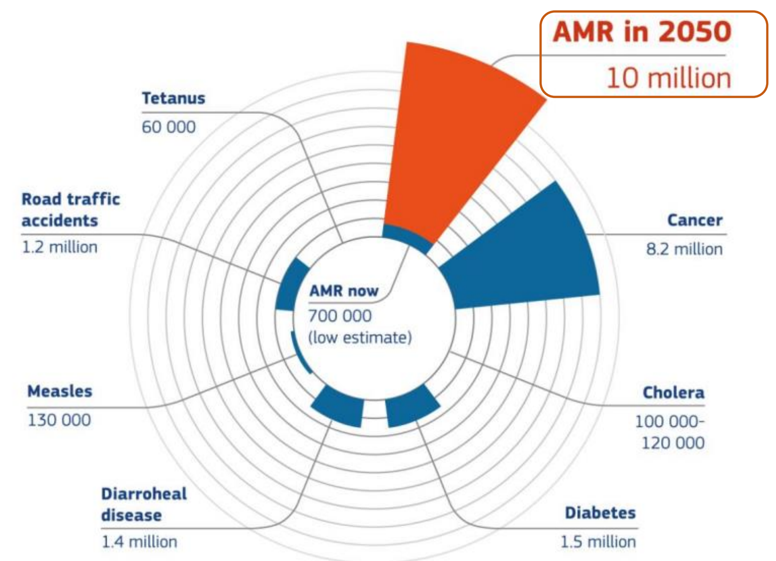


1. Question

- What **limits** the **effectiveness** of common **soaps?**
- Can molecular design & engineering **break** those limits?
- Rigorous hygiene, including hand-washing, is **critical** to prevent the spread of disease, in particular, in high-traffic and time-constrained environments (e.g. hospitals, schools, food handling/processing)

COVID: 20-30s rule highlighted soap's limited efficiency

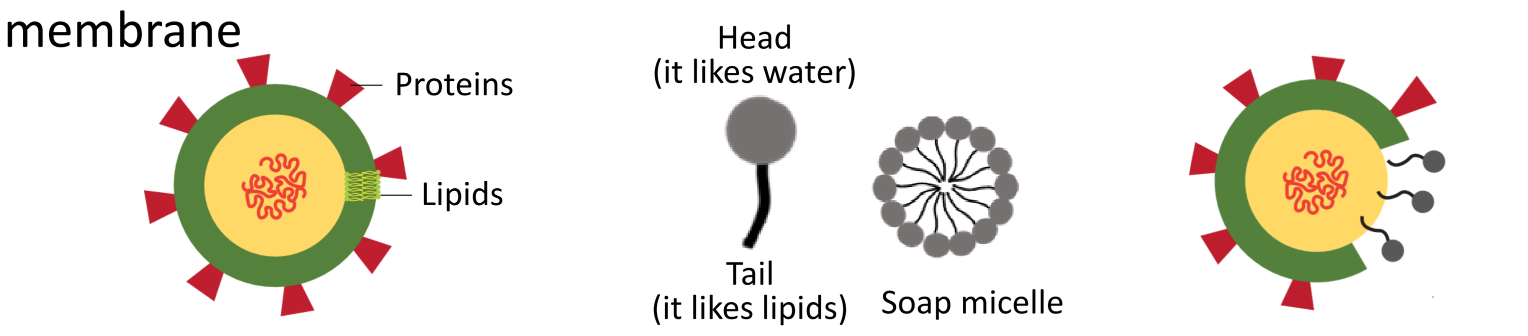


Deaths due to Anti-microbial resistance (AMR) each year[1]

- Alternative anti-biotics usage results in **AMR**
- Covid pandemic reinforced the **importance** of handwashing and hygiene

2. Scientific Background

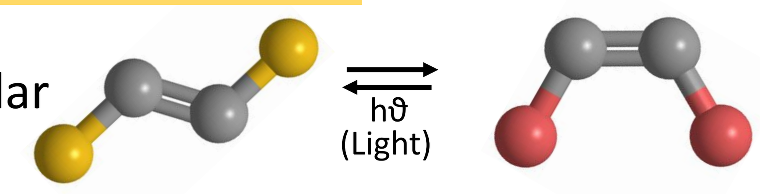
- Soap molecules or surfactants act by disrupting a microbe's outer lipid membrane



Microbes are surrounded by a lipid membrane — Soap is a dual nature molecule — Soap's tail inserts into membrane and breaks it apart

However the disruption is very SLOW (10s of seconds to minutes)[2]

- Photo-switches can **change** molecular shape under **light**

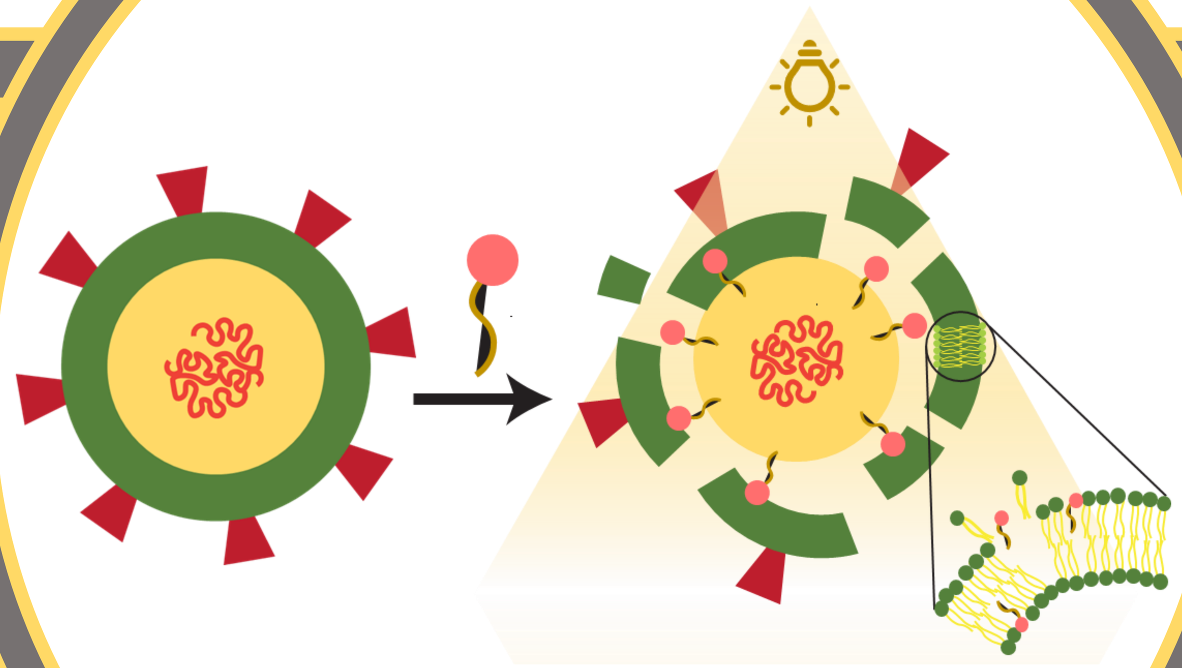


Opposite side **'trans'**, *E* — same side **'cis'** *Z*

- Can **soaps be modified with photo-switch** so they insert quickly and, once inside change shape and **'instantly'(< 1s)** disrupt membrane?

Sneaking in to the membrane as a TROJAN horse for fast action!

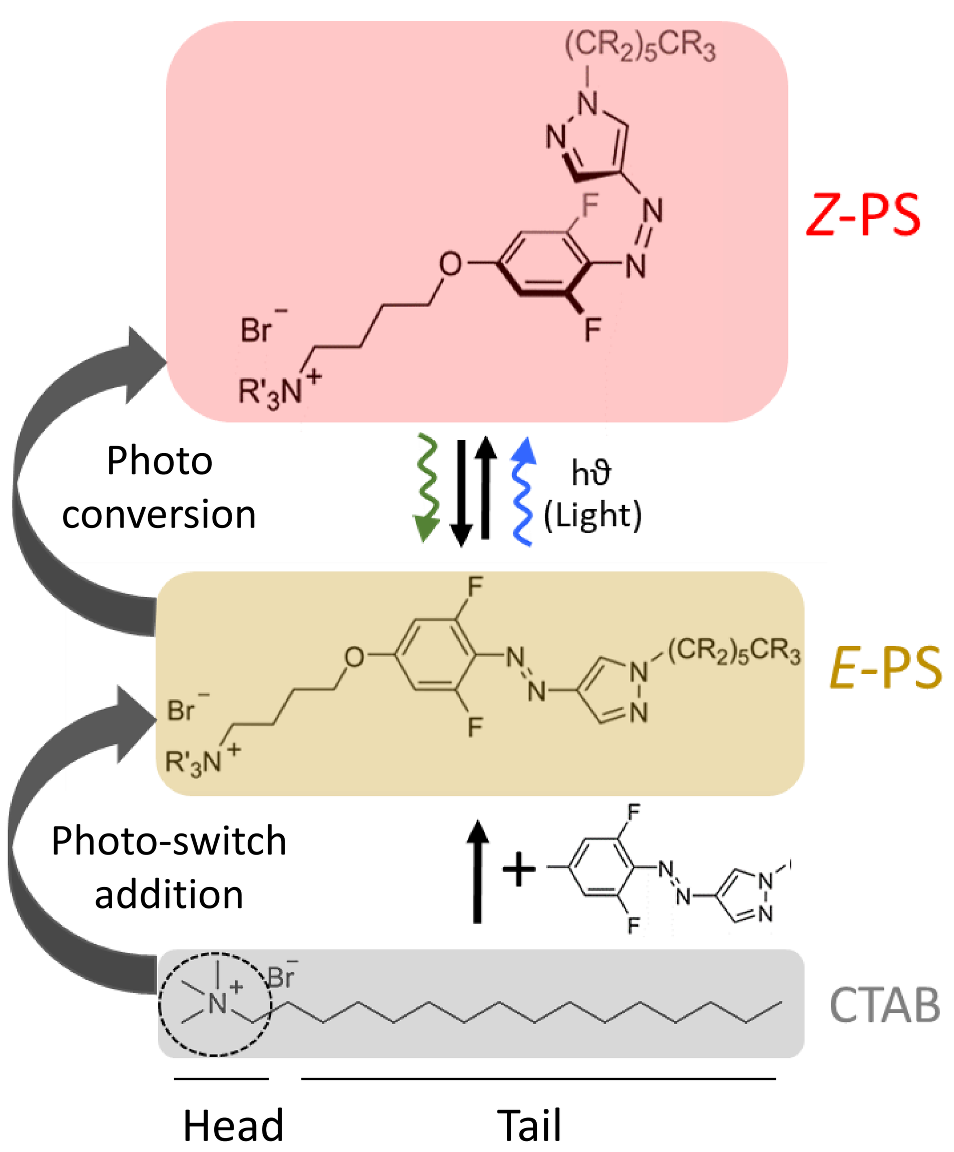
Overview



Fast microbial membrane disruption with TROJAN surfactants

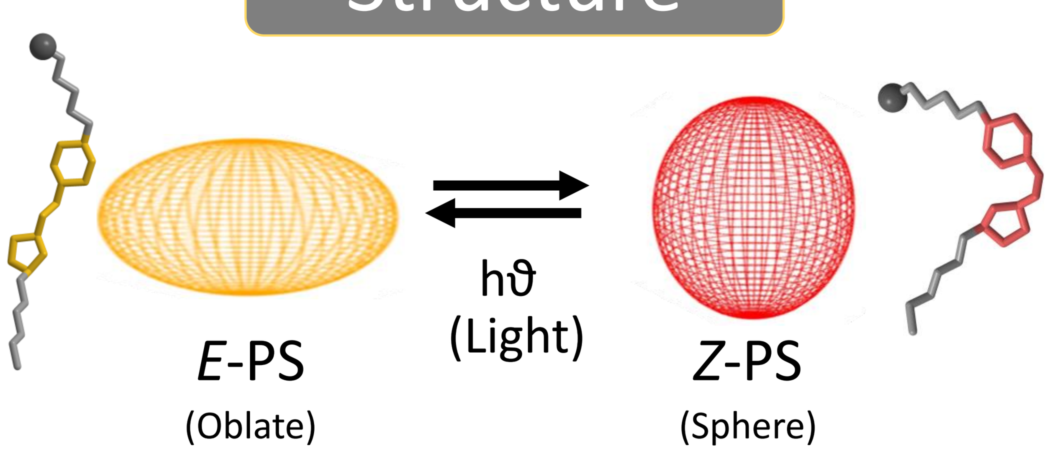
3. Our Concept

Design



A **model photo-switch** (arylazopyrazole) was incorporated into **common soap** CTAB (cetyltrimethylammonium bromide) to make a **photo-surfactant (PS)** in *trans*, ***E*-PS** and *cis* ***Z*-PS** forms

Structure

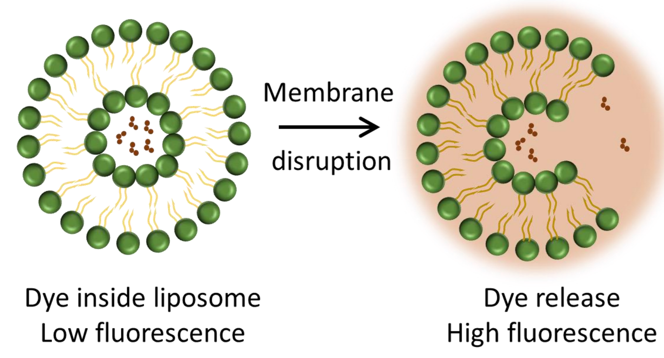


Neutron and X-ray scattering (SANS/SAXS) study

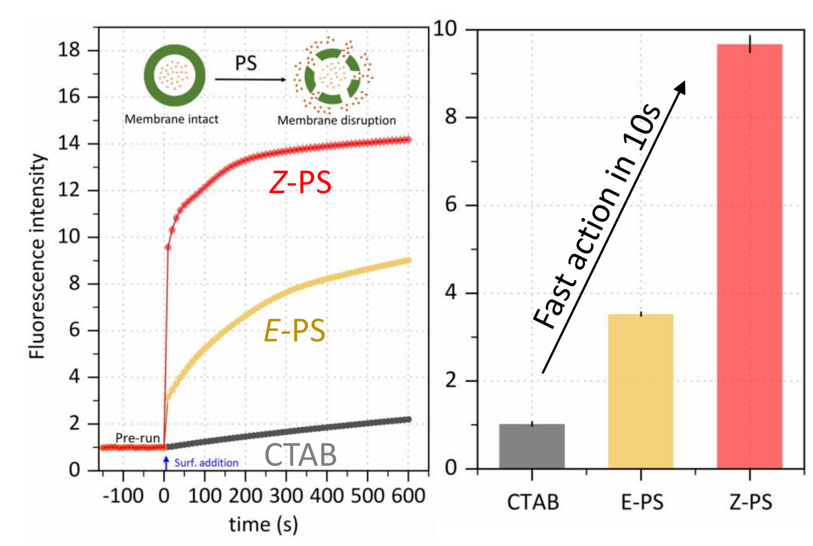
PS self-assemble into micelles and become more **spherical and polar** (water-liking) in response to light: this **affects how quickly they move**

Validation

Kinetics and efficiency of membrane disruption



Liposomes are small spheres made of lipids that look like microbial membrane. When activated by PS, the **dye** inside it **leaks out**, and the fluorescence signal shows that the **membrane is breaking**



E-PS shows 4-fold increase while **Z-PS** shows a **10-fold increase** in fluorescence, barely **within 10s** showing faster membrane disruption[3]

What about cost?

Mixing as little as 10% of PS with common soap provides an amplified response making them cost-effective[3]

4. Impact

- This work **addresses WHO concern** over lack of innovation in the development of novel anti-microbial agents[4]
- Novel light-activated **smart surfactants** will act as a bridge between common soaps and biocidal drugs with potentially significant benefits for health and well being
- The concept **supports the UKRI's mission** of understanding and responding to the pandemic and supporting a resilient and sustainable society[5]

5. Future

- AMR and infection related epidemics are global challenges - ***We must act now!!***
- This work paves the way for next-generation cleaning formulations
- Novel soap molecules responsive to other gentler triggers – small temperature, pH
- Screening against a spectrum of microbes and biofilms

6. References

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1) Review on Anti-microbial Resistance, chaired by Jim O' Neil, supported by UK Govt. and Wellcome Trust, 2016 **2)** Lichtenberg Dov *et al* Biophysical journal 2,105, 289-299, 2013 **3)** Tyagi, Gunjan, et al. JACS Au 2, 12, 2670–2677, 2022 **4)** World Health Organisation, Stratergic Preparedness and Response Plan for the New Coronavirus 2020b **5)**UK Research and Innovation strategy 2022-2027. https://www.ukri.org/wp-content/uploads/2022/03/UKRI-210422-Strategy2022To2027TransformingTomorrowTogether.pdf

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