

Correction

# Correction: Ortelli et al. Design of TiO<sub>2</sub>-Based Hybrid Systems with Multifunctional Properties. *Molecules* 2023, 28, 1863

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There was an error in the original publication [1] regarding the biosurfactant used in this study, which we called ‘Sodium-Surfactin’ (SS). It is more accurately a crude mixture of lipopeptides (LP) derived from bacterial fermentation. This correction is made to avoid potential conflicts of interest in future publications using ‘Surfactin’, a commercial biosurfactant specifically developed for use in cosmetic applications. This is different from the biosurfactant used in this study in the optimization, purification, and characterization processes.

When the specification of the hybrid system is required, ‘Surfactin’ and ‘SS’ are substituted with ‘LipoPeptide’ and ‘LP’, respectively.

## Title Change

The word ‘Surfactin’ in the title is now substituted with ‘Based’.

## Text Correction

In addition to systematic substitution carried out across the text, the authors added the following paragraph to the Introduction, placing it after the third paragraph:

Lipopeptides are a class of biosurfactants that have been widely studied and utilized for various biomedical and environmental applications due to their diverse properties, including antimicrobial, antiadhesive, antitumor, and bioremediation activities [6–12]. Lipopeptides possess surfactant properties due to their amphiphilic nature, having both hydrophilic (peptide) and hydrophobic (lipid) components. This allows them to interact with cell membranes, disrupting their structures and functions. As a result, lipopeptides can exhibit potent antimicrobial effects against a wide range of pathogens, including bacteria, fungi, and even some viruses [13,14].

The authors rephrased the fourth paragraph of the Introduction with the following text:

Lipopeptides also exhibits good stabilizing properties used in the sol–gel synthesis of metal nanoparticles [15–19]. Thus, we decided to exploit the coupling between TiO<sub>2</sub> NPs and a mixture of lipopeptides (LP), to investigate the physicochemical identity of the hybrid phase and the possible synergetic, antagonist, or independent effects in terms of functionality [20,21].

## Errors in Figure/Table Legends and Figures/Tables

The legends and/or texts of Scheme 1, Figures 1, 2, 3, 4, 5, 6, S1, S2, S3, S4, S5, S6 and S8 and Tables 1, 2, 3, 4, 5, 6, S1, S2, and S3 have been corrected. All uses of the abbreviation ‘SS’ (‘Sodium-Surfactin’) have been substituted with ‘LP’ (crude lipopeptide mixture). The corrected Figures and Tables appear below.



**Citation:** Ortelli, S.; Vespignani, M.; Zanoni, I.; Blosi, M.; Vineis, C.; Piancastelli, A.; Baldi, G.; Dami, V.; Albonetti, S.; Costa, A.L. Correction: Ortelli et al. Design of TiO<sub>2</sub>-Based Hybrid Systems with Multifunctional Properties. *Molecules* 2023, 28, 1863. *Molecules* 2024, 29, 4647. <https://doi.org/10.3390/molecules29194647>

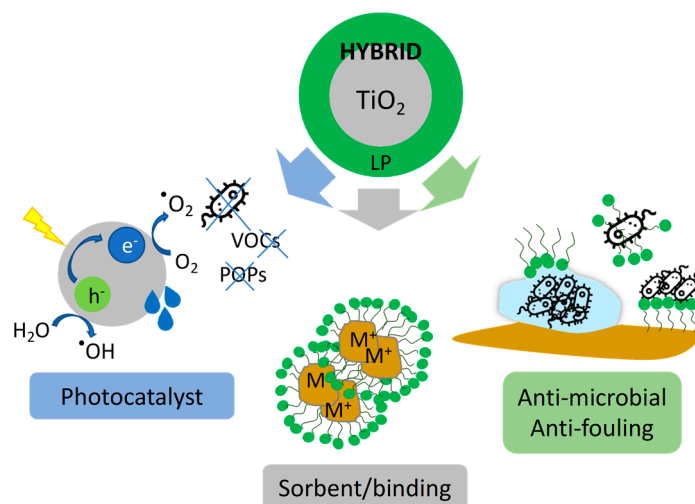
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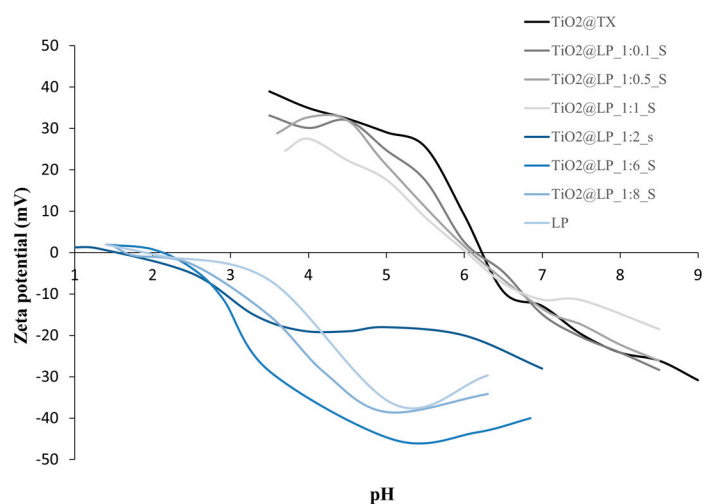
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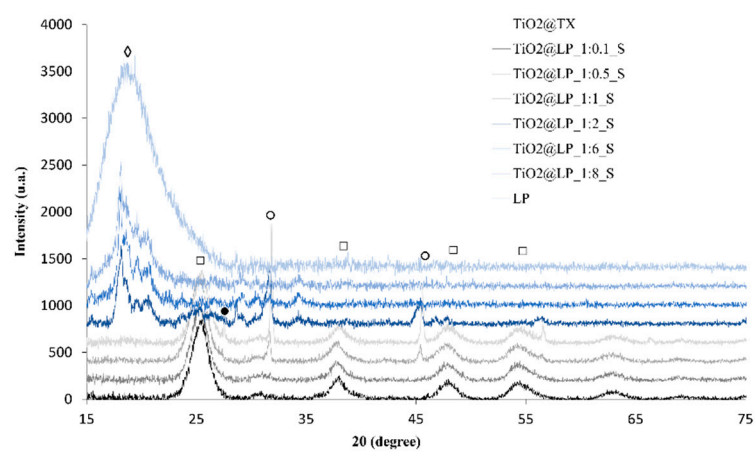
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**Scheme 1.** Multifunctional platform designed for the removal of water/soil pollutants.



**Figure 1.** Zeta potential as a function of pH curves for  $\text{TiO}_2@LP\_S$  samples obtained via sol-gel synthesis.



**Figure 2.** XRD diffractograms of  $\text{TiO}_2@LP\_S\_SFD$  samples ( $\diamond$ , LP;  $\square$ , anatase;  $\bullet$ , brookite;  $\circ$ , sodium chloride).

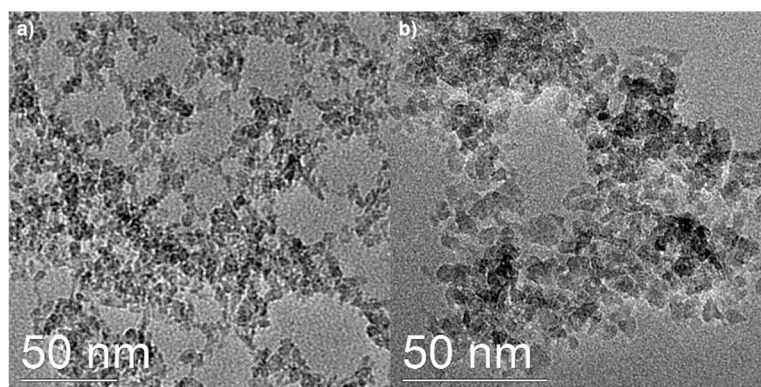


Figure 3. TEM images of (a)  $\text{TiO}_2@LP\_S\_1:0.1$  and (b)  $\text{TiO}_2@LP\_S\_1:1$  samples.

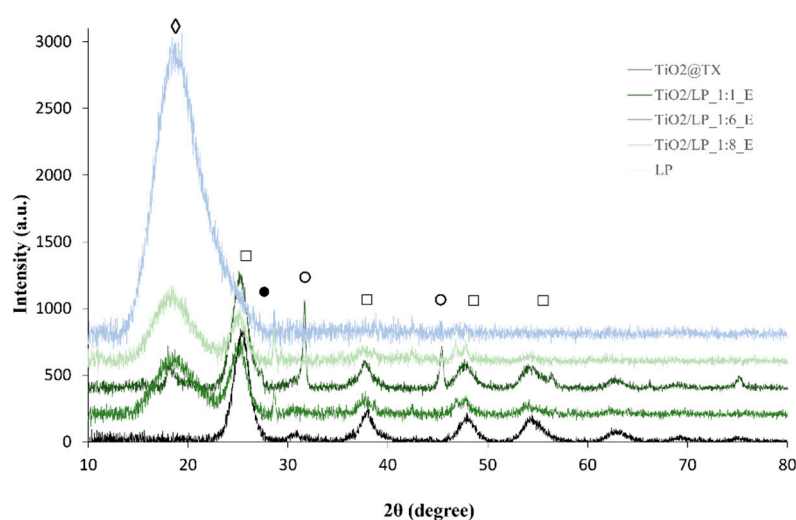


Figure 4. XRD diffractograms of  $\text{TiO}_2/LP\_E\_SFD$  samples ( $\diamond$ , LP;  $\square$ , anatase;  $\bullet$ , brookite;  $\circ$ , sodium chloride).

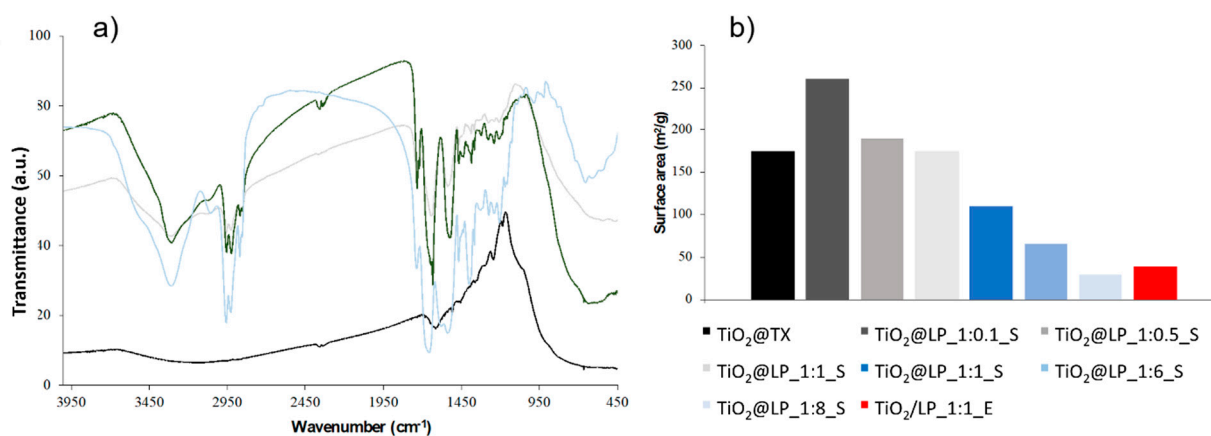
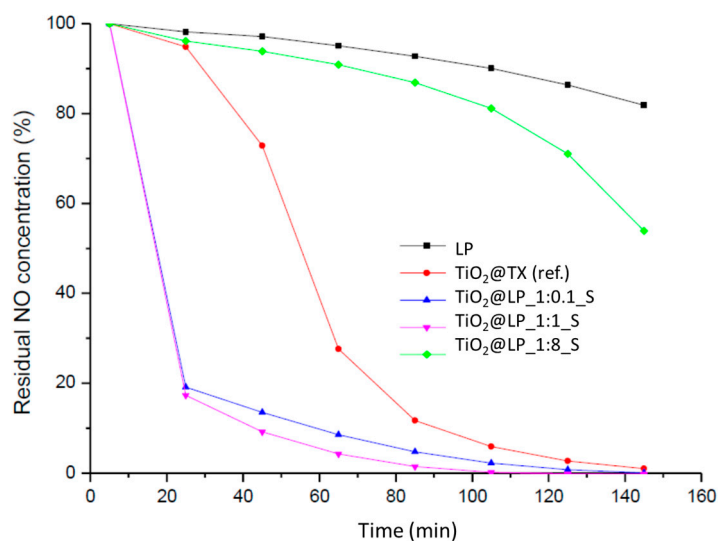


Figure 5. (a) FTIR spectra of  $\text{TiO}_2@TX$  (black), LP (light blue),  $\text{TiO}_2@LP\_1:1\_S$  (light gray), and  $\text{TiO}_2/LP\_1:1\_E$  (dark green) samples and (b) specific surface area data ( $\text{m}^2/\text{g}$ ).



**Figure 6.** NO depletion trend as a function of UV light time of irradiation.

**Table 1.** Data from colloidal characterization of TiO<sub>2</sub>@LP<sub>S</sub> samples obtained via sol–gel synthesis.

Sample	d <sub>DLS</sub> (nm)	Zeta-potELS (mV)	pH <sub>iep</sub>
LP	nd *	−38 ± 6	1.7
TiO <sub>2</sub> @TX	64 ± 2	+39 ± 7	6.2
TiO <sub>2</sub> @LP <sub>1:0.1_S</sub>	77 ± 4	+33 ± 6	6.1
TiO <sub>2</sub> @LP <sub>1:0.5_S</sub>	215 ± 15	+28 ± 5	6.0
TiO <sub>2</sub> @LP <sub>1:1_S</sub>	720 ± 143	+24 ± 4	6.0
TiO <sub>2</sub> @LP <sub>1:2_S</sub>	870 ± 84	−7 ± 2	1.7
TiO <sub>2</sub> @LP <sub>1:6_S</sub>	1000 ± 25	−40 ± 8	2.1
TiO <sub>2</sub> @LP <sub>1:8_S</sub>	1020 ± 178	−43 ± 5	1.7

nd \*, not determined.

**Table 2.** Data from colloidal characterization of TiO<sub>2</sub>/LP<sub>E</sub> samples obtained via heterocoagulation.

Sample	d <sub>DLS</sub> (nm)	Zeta-potELS (mV)	pH <sub>iep</sub>
LP	nd *	−38 ± 6	1.7
TiO <sub>2</sub> @TX	64 ± 2	+39 ± 7	6.2
TiO <sub>2</sub> /LP <sub>1:1_E</sub>	1100 ± 200	−16 ± 4	3.4
TiO <sub>2</sub> /LP <sub>1:6_E</sub>	216 ± 5	−31 ± 58	1.7
TiO <sub>2</sub> /LP <sub>1:8_E</sub>	243 ± 2	−41 ± 5	1.5

nd \*, not determined.

**Table 3.** Conversion (%) and kinetic constant (min<sup>−1</sup>) data obtained via photocatalytic tests of TiO<sub>2</sub>@LP<sub>S</sub> samples synthesized via the sol–gel method.

Sample	Conversion (%)	k (min <sup>−1</sup> )
TiO <sub>2</sub> @TX (ref.)	99	9.5 × 10 <sup>−2</sup>
TiO <sub>2</sub> @LP <sub>1:0.1_S</sub>	99	8.5 × 10 <sup>−2</sup>
TiO <sub>2</sub> @LP <sub>1:0.5_S</sub>	90	4.0 × 10 <sup>−2</sup>
TiO <sub>2</sub> @LP <sub>1:1_S</sub>	87	2.3 × 10 <sup>−2</sup>
TiO <sub>2</sub> @LP <sub>1:2_S</sub>	47	0.6 × 10 <sup>−2</sup>
TiO <sub>2</sub> @LP <sub>1:6_S</sub>	16	0.5 × 10 <sup>−2</sup>
TiO <sub>2</sub> @LP <sub>1:8_S</sub>	12	0.1 × 10 <sup>−2</sup>



**Table 4.** Conversion (%) and kinetic constant ( $\text{min}^{-1}$ ) obtained via photocatalytic tests of  $\text{TiO}_2/\text{LP}_E$  samples prepared via heterocoagulation.

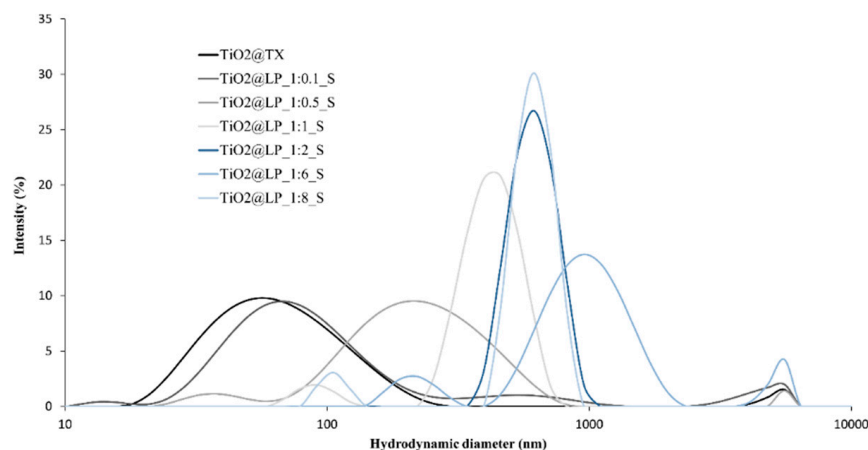
Sample	Conversion (%)	k ( $\text{min}^{-1}$ )
$\text{TiO}_2@\text{TX}$ (ref.)	99	$9.5 \times 10^{-2}$
$\text{TiO}_2/\text{LP}_{1:1}_E$	18	$0.5 \times 10^{-2}$
$\text{TiO}_2/\text{LP}_{1:6}_E$	5	$0.6 \times 10^{-3}$
$\text{TiO}_2/\text{LP}_{1:8}_E$	5	$0.6 \times 10^{-3}$

**Table 5.** Results of  $\text{Cu}^{2+}$  sorption ( $\text{mgCu}^{2+}/\text{g}_{\text{sample}}$ ) tests performed on representative samples.

Sample	$\text{Cu}^{2+}$ Sorption ( $\text{mg Cu}^{2+}/\text{g}_{\text{sample}}$ )	
	1 h	24 h
LP	2.53	2.53
$\text{TiO}_2@\text{TX}$ (ref.)	1.36	1.39
$\text{TiO}_2@\text{LP}_{1:0.1}_S$	1.16	1.28
$\text{TiO}_2@\text{LP}_{1:1}_S$	1.28	1.23
$\text{TiO}_2@\text{LP}_{1:8}_S$	2.53	2.53
$\text{TiO}_2/\text{LP}_{1:1}_E$	1.18	1.35
$\text{TiO}_2/\text{LP}_{1:8}_E$	2.53	2.53

**Table 6.** Results of antibacterial tests performed on representative samples.

Sample	Add-on (%)	Bacterial Reduction (%)
LP	1.7	40
$\text{TiO}_2@\text{TX}$ (ref.)	3.1	72
$\text{TiO}_2@\text{LP}_{1:0.1}_S$	3.9	89
$\text{TiO}_2@\text{LP}_{1:1}_S$	3.9	85
$\text{TiO}_2@\text{LP}_{1:8}_S$	5.3	77

**Figure S1.** Particle size distribution of  $\text{TiO}_2@\text{LP}$  samples obtained via the sol-gel synthesis method.

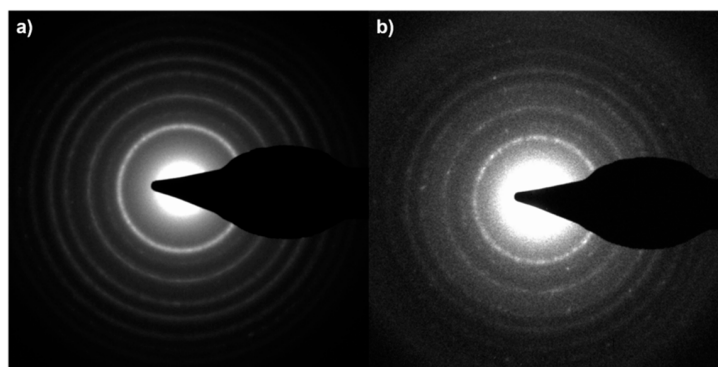


Figure S2. SAED patterns of the (a)  $\text{TiO}_2@LP\_S\_1:0.1$  and (b)  $\text{TiO}_2@LP\_S\_1:1$  samples.

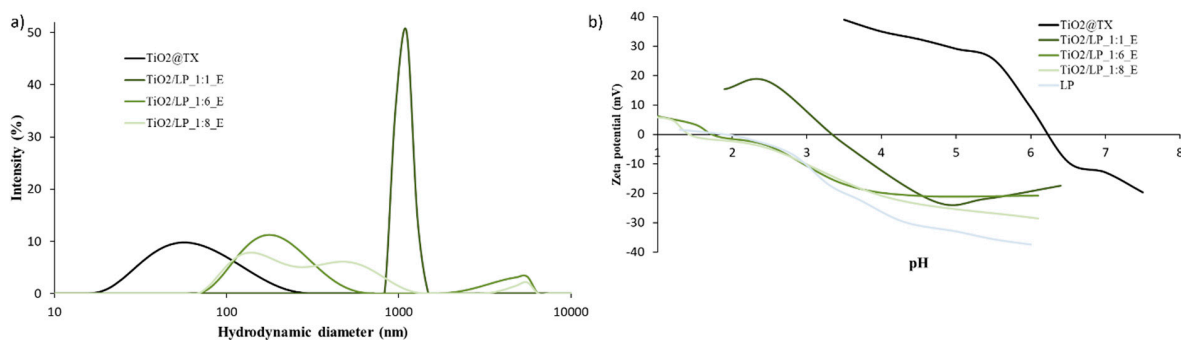


Figure S3. (a) Particle size distribution and (b) Zeta potential as a function of pH curves of  $\text{TiO}_2/LP\_E$  samples obtained via the heterocoagulation process.

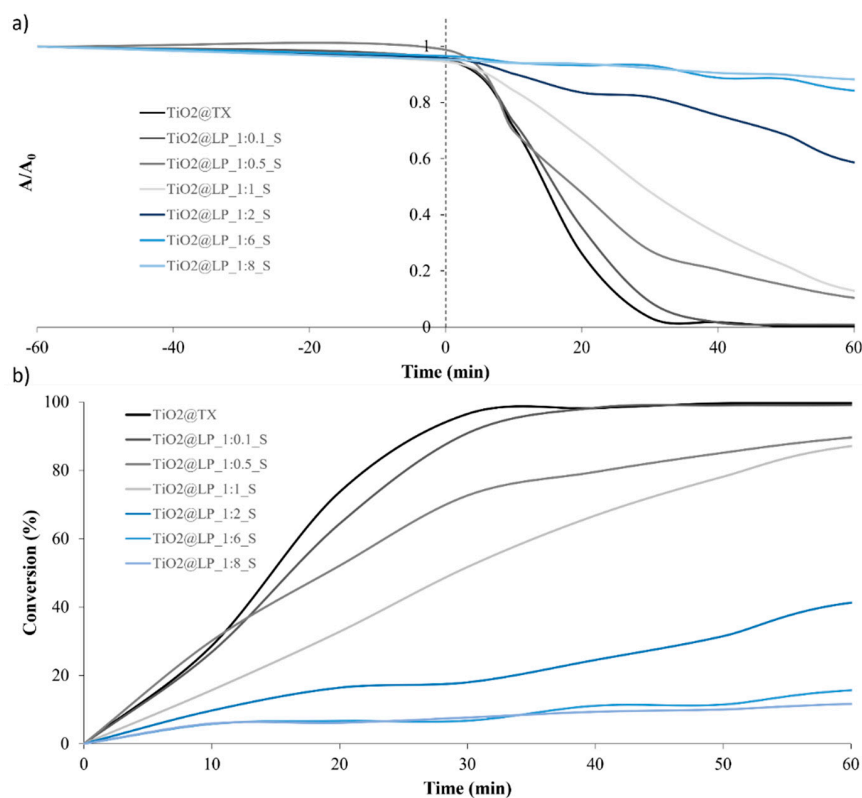
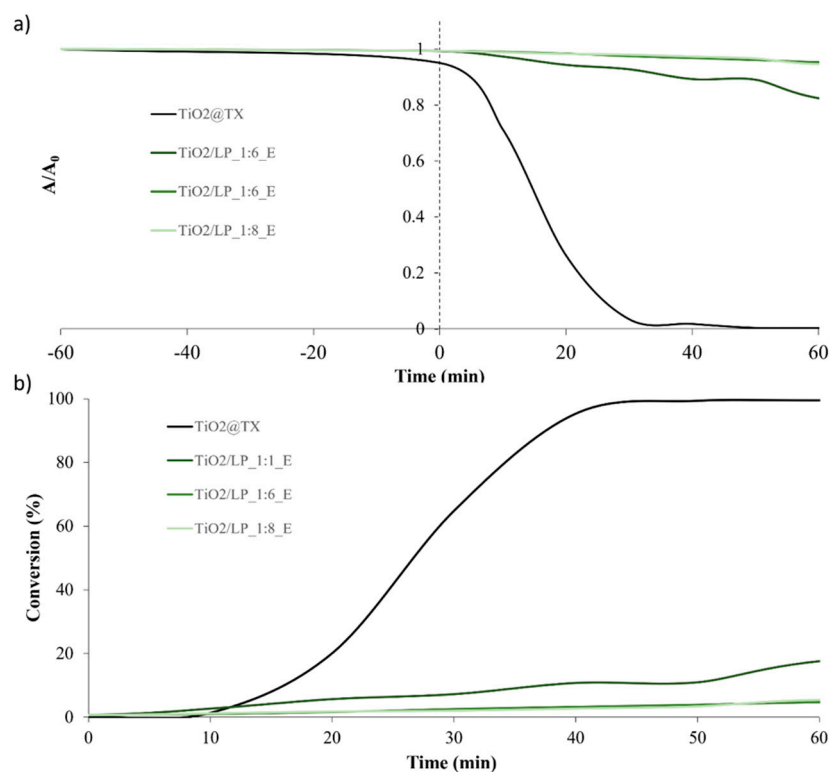
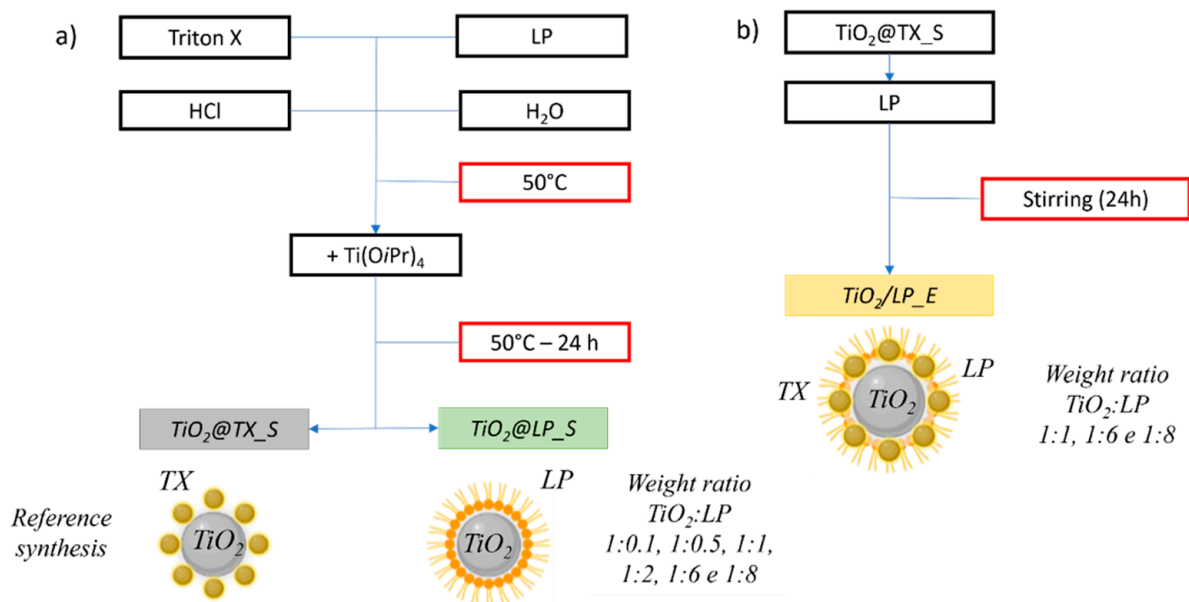


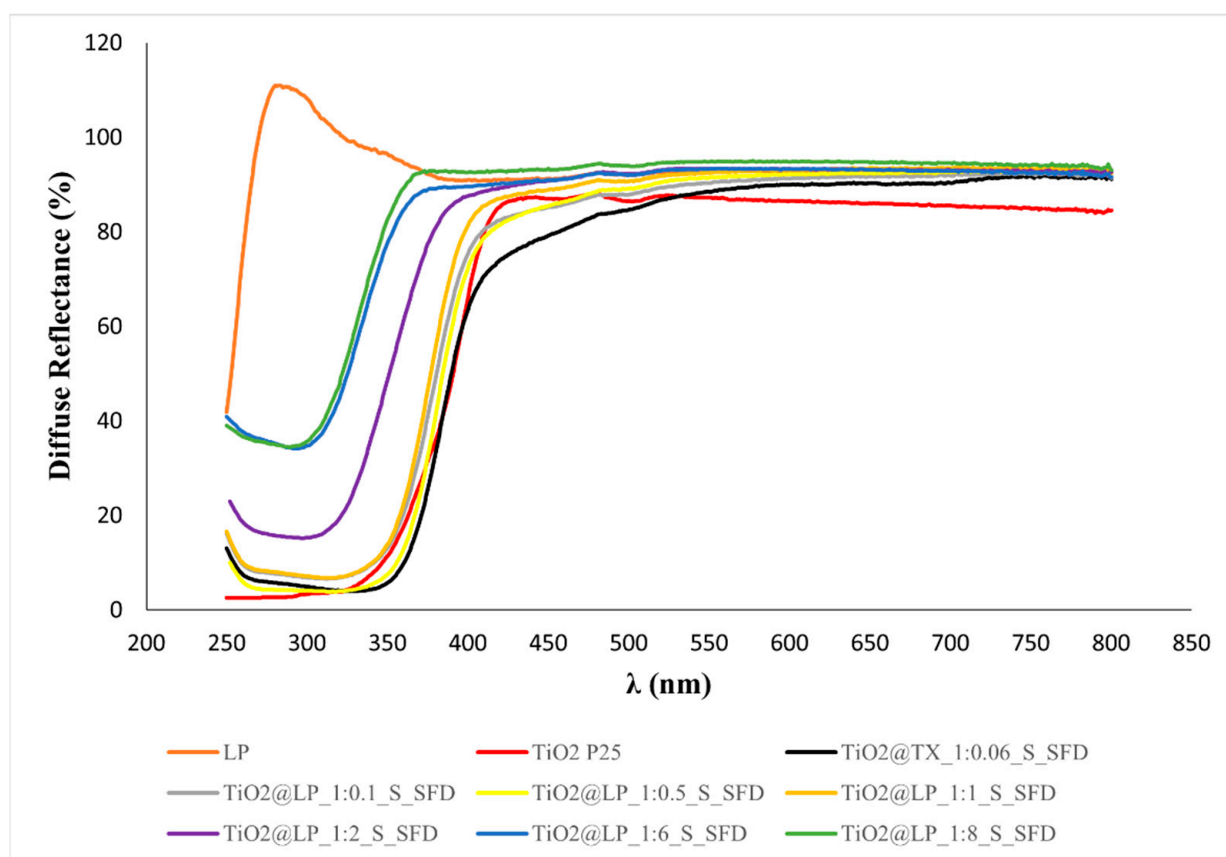
Figure S4. (a) Trends of  $A/A_0$  and (b) conversion (%) over time for  $\text{TiO}_2@LP\_S$  samples obtained via the sol-gel synthesis method.



**Figure S5.** (a) Trends of  $A/A_0$  and (b) conversion (%) over time for  $TiO_2/LP_E$  samples obtained via the heterocoagulation process.



**Figure S6.** Scheme of (a) sol-gel processes using Triton X (TX) and mixture of lipopeptides (LP) as a surfactant and (b) the heterocoagulation process.



**Figure S8.** Diffuse reflectance over different wavelengths of  $\text{TiO}_2@LP_S$  samples.

**Table S1.** Sample codes and  $\text{TiO}_2$ :LP weight ratios of nanosols obtained via the sol-gel synthesis process and relative powders obtained via the SFD process.

Sample Code		$\text{TiO}_2$ :LP Weight Ratio
Nanosol	Powder	
$\text{TiO}_2@LP_1:0.1_S$	$\text{TiO}_2@LP_1:0.1_S\_SFD$	10.0
$\text{TiO}_2@LP_1:0.5_S$	$\text{TiO}_2@LP_1:0.5_S\_SFD$	2.0
$\text{TiO}_2@LP_1:1_S$	$\text{TiO}_2@LP_1:1_S\_SFD$	1.0
$\text{TiO}_2@LP_1:2_S$	$\text{TiO}_2@LP_1:2_S\_SFD$	0.5
$\text{TiO}_2@LP_1:6_S$	$\text{TiO}_2@LP_1:6_S\_SFD$	0.17
$\text{TiO}_2@LP_1:8_S$	$\text{TiO}_2@LP_1:8_S\_SFD$	0.13
$\text{TiO}_2@TX_S$	$\text{TiO}_2@TX_S\_SFD$	16.7 *

\*  $\text{TiO}_2$ :Triton X weight ratio.

**Table S2.** Sample codes and  $\text{TiO}_2$ :LP weight ratios of nanosols obtained via the heterocoagulation process and relative powders obtained via the SFD process.

Sample Code		$\text{TiO}_2$ :LP Weight Ratio
Nanosol Sample	Powder Sample	
$\text{TiO}_2/LP_1:1_E$	$\text{TiO}_2/LP_1:1\_E\_SFD$	1.0
$\text{TiO}_2/LP_1:6_E$	$\text{TiO}_2/LP_1:6\_E\_SFD$	0.17
$\text{TiO}_2/LP_1:8_E$	$\text{TiO}_2/LP_1:8\_E\_SFD$	0.13

The  $\text{TiO}_2$  used to produce the heterocoagulated samples is  $\text{TiO}_2@TX_S$  of Table S1 (containing around 6 wt.% of Triton X).

**Table S3.** Adsorption properties derived by UV-Vis analysis.

Powder Sample Code	Absorption Range (nm)	Band Gap Energy (eV)
TiO <sub>2</sub> @TX_SFD	350–450	3.14
TiO <sub>2</sub> P25 *	350–420	3.19
TiO <sub>2</sub> @LP_1:0.1_S_SFD	350–420	3.17
TiO <sub>2</sub> @LP_1:0.5_S_SFD	350–420	3.18
TiO <sub>2</sub> @LP_1:1_S_SFD	350–420	3.18
TiO <sub>2</sub> @LP_1:2_S_SFD	300–380	3.33
TiO <sub>2</sub> @LP_1:6_S_SFD	300–360	3.41
TiO <sub>2</sub> @LP_1:8_S_SFD	300–360	3.41

\* TiO<sub>2</sub> P25 (commercial powder sample from Degussa-Evonik).

### Revised References

Previous references focused exclusively on Surfactin. Due to the proposed correction (substitution of Surfactin with a mixture of lipopeptides), it was necessary to revise references specifically addressing lipopeptides to strengthen the rationale behind this study.

References 7 and 10 from the original publication [1] have now been removed. Also, the following citations have now been inserted as references 6, 10, 12, 15, and 16 into the Introduction. With this correction, the order of some references has been adjusted accordingly.

- Meena, K.R.; Kanwar, S.S. Lipopeptides as Antifungal and Antibacterial Agents: Applications in Food Safety and Therapeutics. *BioMed Res. Int.* **2015**, *2015*, 473050. <https://doi.org/10.1155/2015/473050>.
- Inès, M.; Dhouha, G. Lipopeptide Surfactants: Production, Recovery and Pore Forming Capacity. *Peptides* **2015**, *71*, 100–112. <https://doi.org/10.1016/j.peptides.2015.07.006>.
- Kourmentza, C.; Freitas, F.; Alves, V.; Reis, M.A.M. Microbial conversion of waste and surplus materials into high-value added products: the case of biosurfactants. In *Microbial Applications*; Kalia, V., Kumar, P., Eds.; Springer: Cham, Switzerland, 2017; Volume 1, pp. 29–77. [https://doi.org/10.1007/978-3-319-52666-9\\_2](https://doi.org/10.1007/978-3-319-52666-9_2).
- Sharma, R.K.; Dey, G.; Banerjee, P.; Maity, J.P.; Lu, C.M.; Siddique, J.A.; Wang, S.C.; Chatterjee, N.; Das, K.; Chen, C.Y. New Aspects of Lipopeptide-Incorporated Nanoparticle Synthesis and Recent Advancements in Biomedical and Environmental Sciences: A Review. *J. Mater. Chem. B* **2023**, *11*, 10–32. <https://doi.org/10.1039/D2TB01564A>.
- Christopher, F.C.; Ponnusamy, S.K.; Ganesan, J.J.; Ramamurthy, R. Investigating the Prospects of Bacterial Biosurfactants for Metal Nanoparticle Synthesis—A Comprehensive Review. *IET Nanobiotechnol.* **2019**, *13*, 243. <https://doi.org/10.1049/iet-nbt.2018.5184>.

### Missing Conflict of Interest

In the original publication [1], the Conflicts of Interest statement of authors Giovanni Baldi and Valentina Dami were not included. The updated Conflict of Interest has been added as follows:

Giovanni Baldi and Valentina Dami was employed by the company Ce.Ri.Col, Colobbia Consulting S.R.L. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

### Author's Information

This article has been republished with a minor update to the correspondence contact information.

The authors state that the scientific conclusions are unaffected. This correction was approved by the Academic Editor. The original publication has also been updated.

## Reference

1. Ortelli, S.; Vespignani, M.; Zanoni, I.; Blosi, M.; Vineis, C.; Piancastelli, A.; Baldi, G.; Dami, V.; Albonetti, S.; Costa, A.L. Design of TiO<sub>2</sub>-Surfactin Hybrid Systems with Multifunctional Properties. *Molecules* **2023**, *28*, 1863. [[CrossRef](#)] [[PubMed](#)]

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