XV Targi Wynalazków i Innowacji INTARG® 2022

Breakthrough for tomorrow's dentistry: Completely safe, the new generation of light-curing dental composites, free of toxic substances and with reduced polymerization shrinkage

Monika Topa-Skwarczyńska[1,3], Małgorzata Noworyta[1], Weronika Wałczyk[1], Joanna Ortyl[1,2,3]

[1]*Cracow University of Technology, Faculty of Chemical Engineering and Technology, Laboratory of Photochemistry and Optical Spectroscopy, Warszawska 24 St. 31-155 Cracow, Poland,*
[2]*Photo HiTech Ltd., Bobrzyńskiego 14, 30-348 Kraków, Poland*
[3]*Photo4Chem sp. z o.o.., Lea 114, 30-133 Kraków, Poland*
Contact: monika.topa@doktorant.pk.edu.pl, jortyl@pk.edu.pl

MOTIVATION

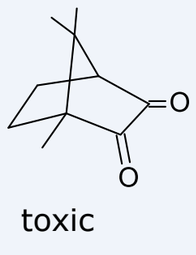
Organic matrix

The most commonly used photo-cured dental materials are dimethacrylic compounds, which guarantee the production of high crosslinking networks. Nevertheless, these monomers have significant polymerization shrinkage, which is not decent in the dentist. It is well known that cationic monomers have a very low polymerization shrinkage. Therefore, in our work, we believed that the use of photocurable systems containing more than one type of monomer with different polymerization mechanisms is an interesting alternative for conventional free-radical cross-linking dimethacrylates organic matrix. Dual cure formulations based on a combination of cationic monomer and free-radical-type monomer can form interpenetrating networks to adjust the photopolymerization rate and cross-linking density suitable and; therefore, control the final properties for dental applications.

The main advantage of these IPNs is that they combine the properties of the two kinds of polymer network. The photocured, interpenetrating polymer networks seem to be a promising way to obtain photocurable polymeric materials characterized by improved properties, such as high-damping effect, lower shrinkage upon photopolymerization and better adhesion properties.

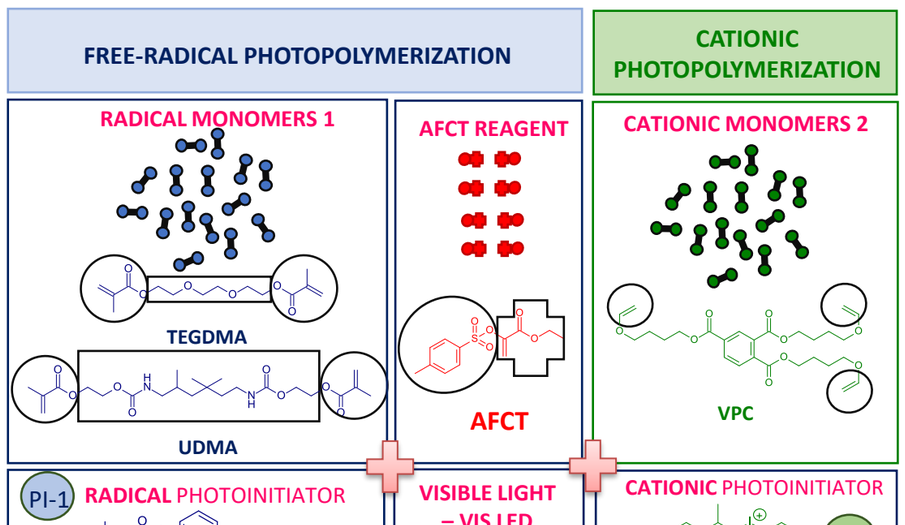
Disadvantages of standard initiating system

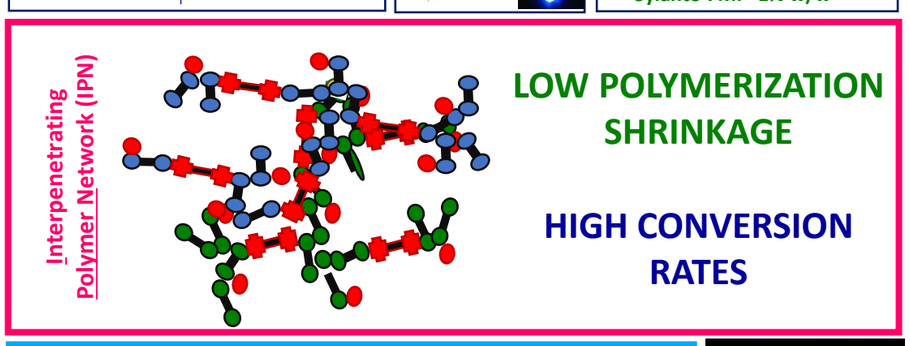
On the other hand, the commonly used photoinitiating system for the radical photopolymerization process is the system based on camphorquinone / aromatic amine. In the step of generating radicals in the photolysis process, amine interacted with the excited camphorquinone molecule. This process involves the transfer of the electron from the amine to the ketone, followed by the abstraction of the proton. The radicals initiating the polymerization process are mainly radicals formed from amines. The basic problem of this system is the fact that too high a concentration of camphorquinone in dental composites may generate a yellow color. Such discoloration can influence the aesthetics and quality of the final product. In addition, amines are cytotoxic and genotoxic factors.

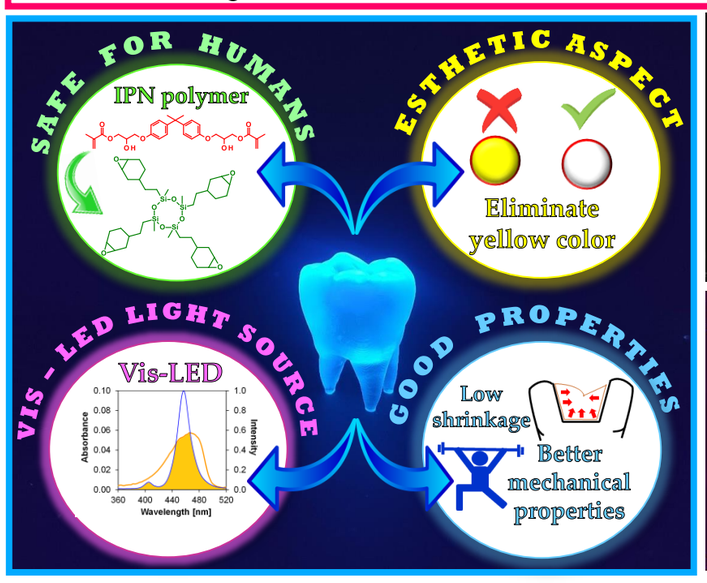


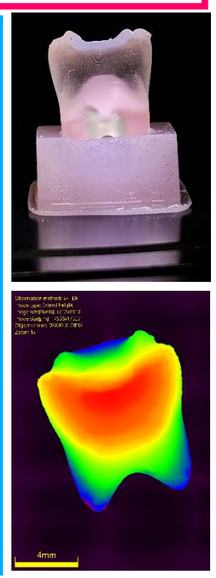
- toxic
- lack of color stability
- CQ generates a yellow color

OUR APPROACH









EXCELLENT SPECTROSCOPIC PROPERTIES

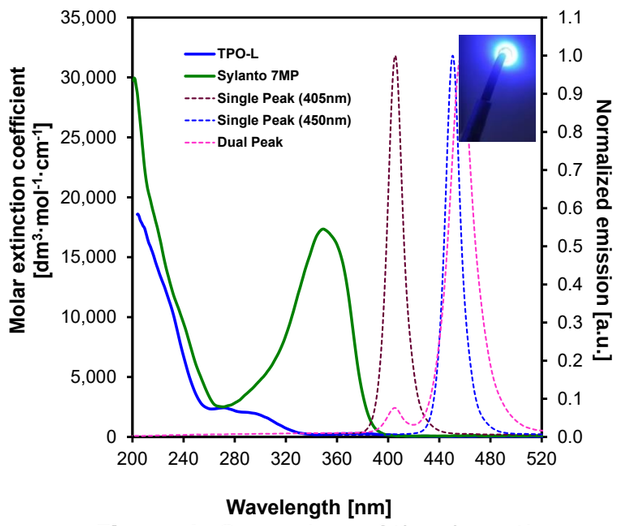


Figure 1. Comparison of the absorption characteristics of photoinitiators: Sylanto 7MP and TPO-L in acetonitrile with the emission characteristics of the dental lamp D -LIGHT® PR.

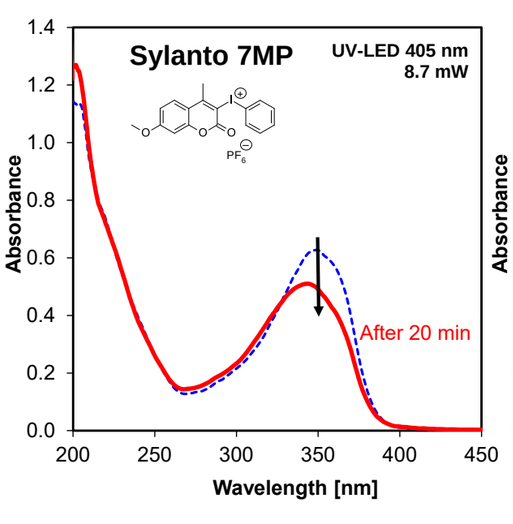


Figure 2. Steady state photolysis of Sylanto 7MP under irradiation upon Vis-LED at 405 nm (8.7 mW/cm²).

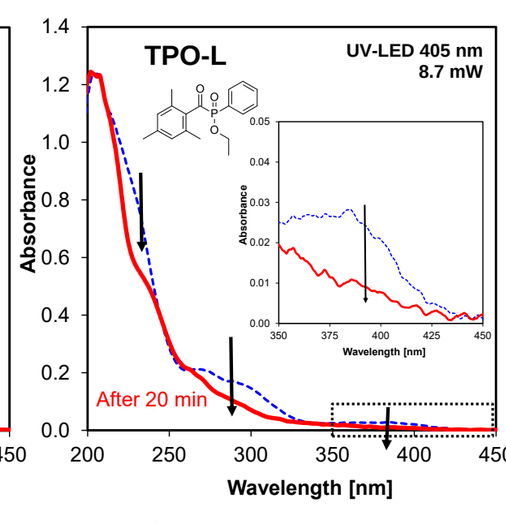


Figure 3. Steady state photolysis of TPO-L under irradiation upon Vis-LED at 405 nm (8.7 mW/cm²).

FAST PHOTOPOLYMERIZATION PROCESS AND COMPLETE PHOTOBLEACHING

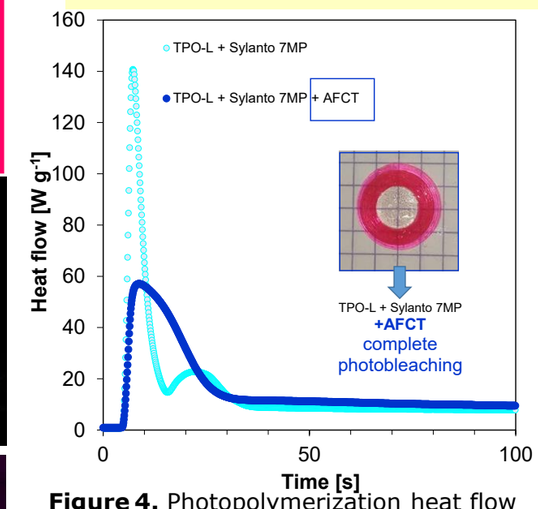
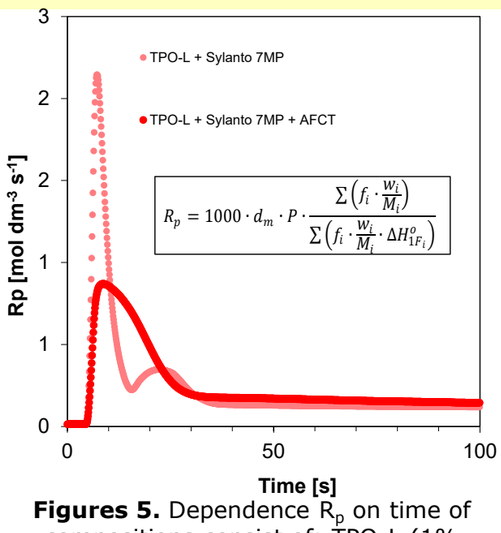


Figure 4. Photopolymerization heat flow curves of compositions consist of: TPO-L (1% w/w), Sylanto 7MP (1% w/w) and mixture of UDMA/TEGDMA/VCP monomers (weight ratio: 0.35 / 0.15 / 0.5) with or without AFCT upon exposure to the Omnicure lamp with a 400-500nm filter and an intensity of 22 mW/cm². The tests were performed with the use of the Photo-DSC 204 F1 Phoenix® apparatus.



Figures 5. Dependence R_p on time of compositions consist of: TPO-L (1% w/w), Sylanto 7MP (1% w/w) and mixture of UDMA/TEGDMA/VCP monomers (weight ratio: 0.35 / 0.15 / 0.5) with or without AFCT upon exposure to the Omnicure lamp with a 400-500nm filter and an intensity of 22 mW/cm². The tests were performed with the use of the Photo-DSC 204 F1 Phoenix® apparatus.

REDUCION OF POLYMERIZATION SHRINKAGE

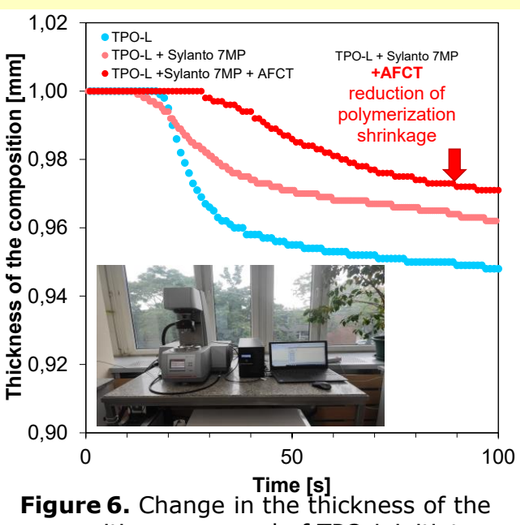
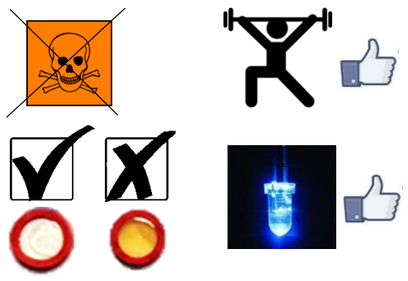


Figure 6. Change in the thickness of the composition composed of TPO-L initiators (1% w/w) or TPO-L initiator mixture (1% w/w) Sylanto 7MP (1% w/w) and mixture of UDMA / TEGDMA / VCP monomers (weight ratio: 0.35 / 0.15 / 0.5) with or without AFCT upon exposure to the Omnicure lamp with a 400-500nm filter and an intensity of 22 mW /cm². The tests were performed with the use of the Modular Compact Rheometer MCR302e

OUR NEW GENERATION DENTAL COMPOSITES

- They are **completely safe for humans** - elimination of cytotoxic amines
- **They do not generate yellow color** - elimination of camphorquinone, greater aesthetics and quality of the final product are preserved.
- Due to the use of polymerizable monomers according to the cationic mechanism, have a **reduced polymerization shrinkage**.
- For the curing process it is possible to use dental lamps emitting **radiation in the visible light range**, eliminating harmful UV radiation.



Monika Topa-Skwarczyńska is a PhD graduate student at the Faculty of Chemical Engineering and Technology, Cracow University of Technology (Poland) in prof. Joanna Ortyl research team. To date, she has actively participated as the contractor in **5** research projects led by prof. Ortyl. Currently she is the manager of **3** projects: Diamond Grant-MNiSW, Prelude-NCN and commercial project TRL 4.0-MNiSW. She is the co-author of **49** publications including **15** published in peer-reviewed journals from the JCR list and **5** patents. She has actively participated in **21** scientific conferences, including **14** international conferences. Her research results have already been recognised both at the national and international arena. She has received nearly 40 awards for the presented results, which undoubtedly proves the innovation of her research. The most important are:

- ✓ **Finalist in the "25 under 25" competition in the Science category organised by Forbes magazine and McKinsey & Company office. 29.01.2020 Warsaw**
- ✓ Winner of the Shesnnovation Academy 2019/20, 06.10.2019
- ✓ Distinction in "Gold medal of chemistry 2017" 05.12.2017 Warsaw
- ✓ First place in the national competition "MŁODY WYNALAZCA 2017" 22.06.2017 Katowice

This work was financed by the National Science Centre as a research project no. 2019/33/N/ST5/03015 "Development and evaluation of physicochemical and mechanical properties of photocurable polymer composites with reduction polymerization shrinkage under visible light" under the **"PRELUDIUM" program**