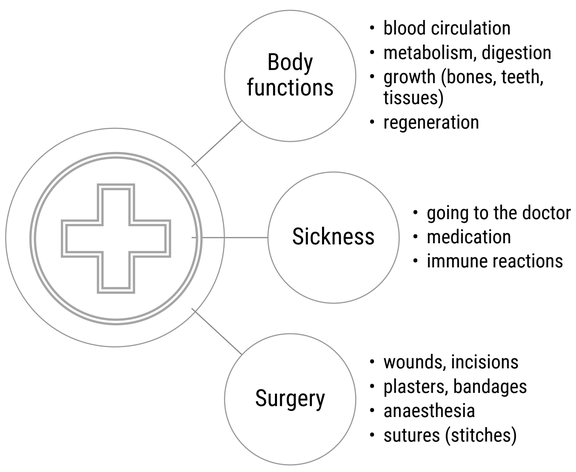
Medical Aspects of Polymers in Surgical Suture Materials for Chemistry Education

Elisabeth Dietel* & Prof. Dr. Timm Wilke

Medicine and Chemistry | **Didactic Opportunities** | **Experimental Series**

Chemistry might not be the first association to come in mind when thinking of **medicine**, but there are many **overlaps** between those disciplines (Fig. 1). Chemistry can help us understand our body functions as well as the mode of action of medical treatments.



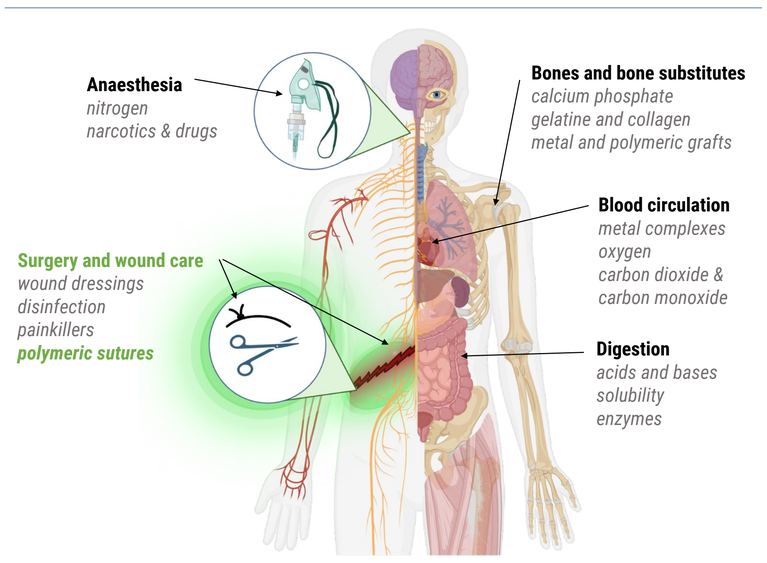


Fig. 1: Selection of overlaps between medicine and chemistry.

Surgical Suture Materials

Having **surgery** means surgeons **close incisions**. Removing **non-degradable sutures**, *e.g.*, PROLENE™ (Fig. 2), in our skin 2 weeks after surgery is a standard procedure, but what about sutures in internal tissues? Three of the most used sutures in tissue or orthopedic surgery are PDS II™, MAXON™ and VICRYL™ (Fig. 3). They consist of poly-p-dioxanone, polyglyconate, and polylactide-co-glycolide (1:9) respectively (Fig. 3) and are **fully resorbable** by our body so there is no second operation needed to remove them. [1, 2]

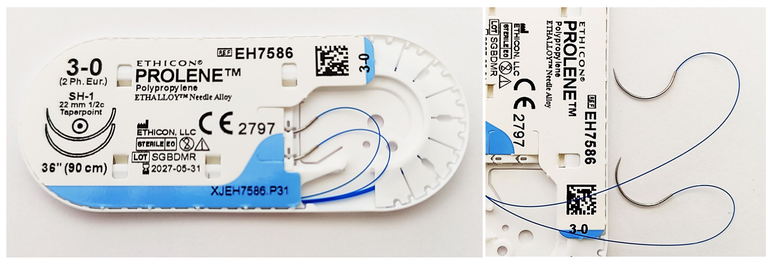


Fig. 2: Surgical sutures, authentic material.

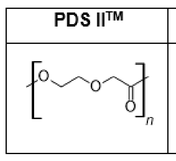
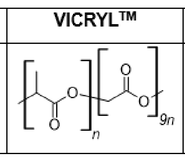
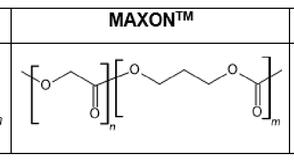
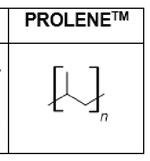
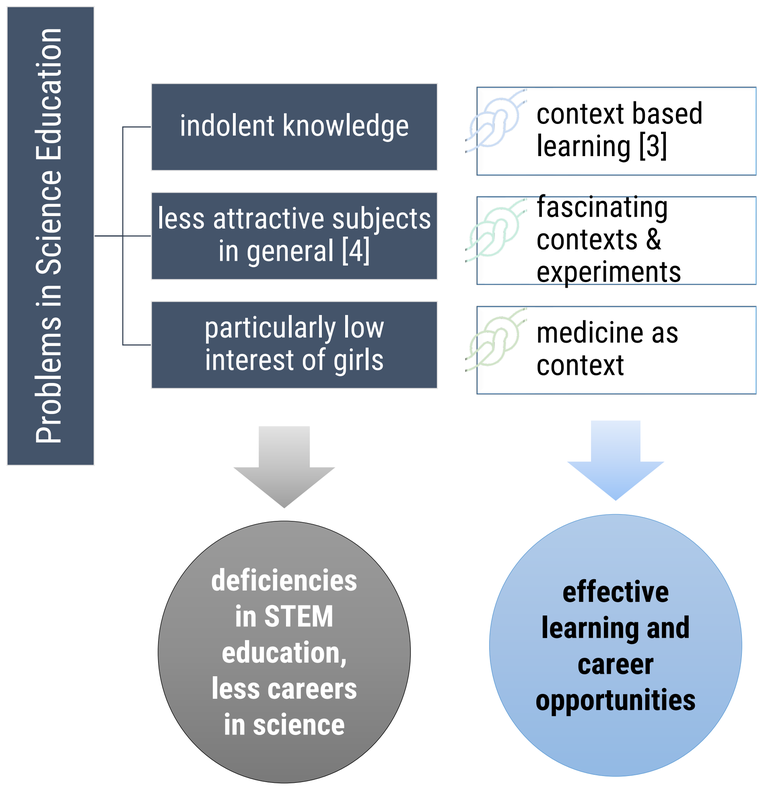
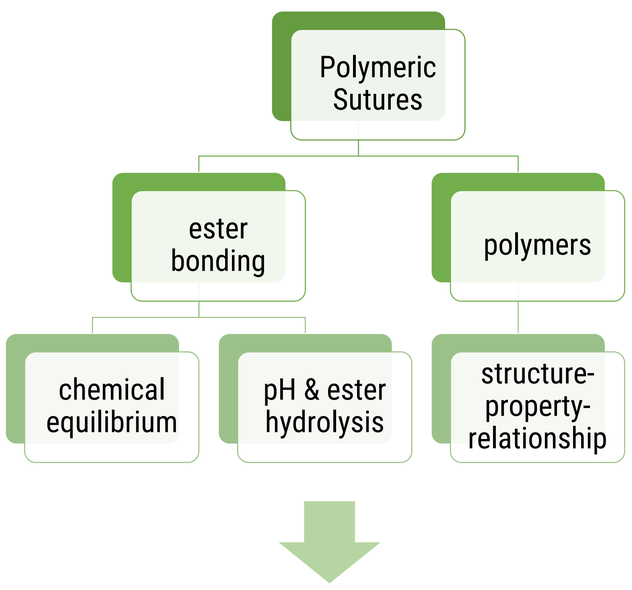
PDS II™	VICRYL™	MAXON™	PROLENE™
			

Fig. 3: Molecular formula of the sutures.



Using surgical sutures as a topic offers **linkage to classical elements of the K-12 curriculum** such as polymers, especially polyesters, ester cleavage, the pH scale, and to basic concepts like structure-property-relationships.



Teaching polymer chemistry and ester bonding
Experimental series with polymeric sutures

The experiments will be embedded in a learning arrangement using the approach of **context-based learning** [3]. Therefore, it will be expanded by related medical topics to build a **holistic learning environment**. Finally, various contextualised learning arrangements will be merged to form one unit. Orientating to the pathways of the **Model of Educational Transfer Research** (Fig. 4) [5], the series will be piloted, evaluated, and optimised.

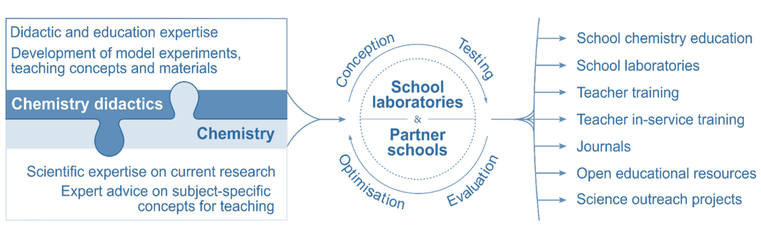


Fig. 4: Model of Educational Transfer Research [5].

We present a **series of experiments suitable for K-12 chemistry education** based on research on degradation behaviour and tensile strength of suture materials [2, 6] as well as on didactic implementations of polymerization [7].

Aim of the experiments:
Simplified demonstration of differences in polyester degradation behaviour

Usability for chemistry education:
Common school equipment, non-toxic and inexpensive chemicals, easily conductible by students

Polymeric sutures in alkaline environment

Incubation in 1 M NaOH:
Observable disintegration (Fig. 5) and dissolvement in different time periods
comparison: no degradation with PROLENE™

Simplified tensile strength measurement:
Testing with a spring force meter
Observable strength loss after incubation for all sutures except PROLENE™

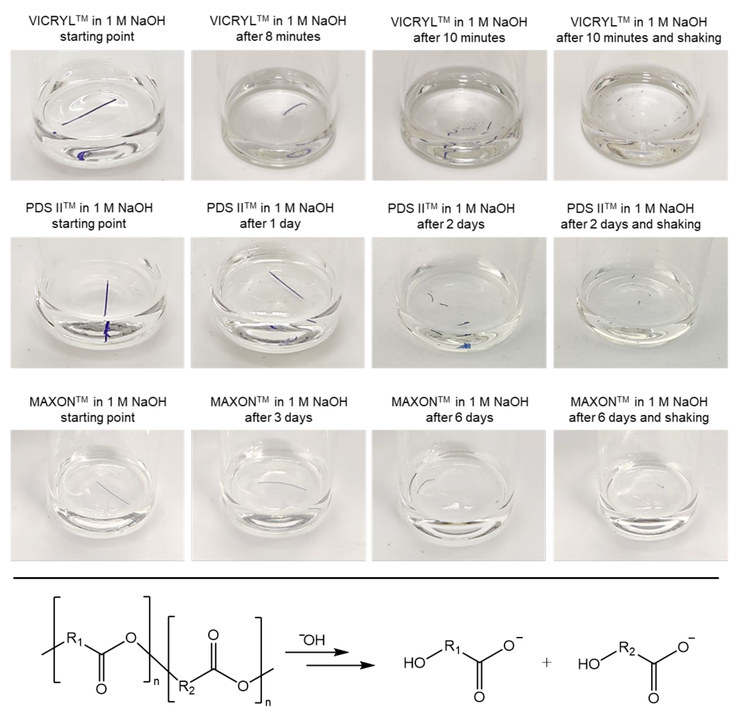


Fig. 5: Degradation behaviour with relevant changes over time (top) and general hydrolysis equation (bottom).

Degradation becomes visible not until **disintegration** into pieces (Fig. 5). Tensile strength measurement contributes to the understanding that irrespective of disintegration degradation results in **strength loss** of the suture pieces.

References

[1] Chellamani, K. P., Veerasubramanian, D., Vignseh Balaji, R. S. (**2013**). Surgical sutures: an overview. *J. Acad. Indus. Res.* **12**/1, 778–782. [2] Pillai, C. K. S., Sharma, C. P. (**2010**). Review paper: absorbable polymeric surgical sutures: chemistry, production, properties, biodegradability, and performance. *Journal of biomaterials applications* **25**/4, 291–366. [3] Demuth, R., Gräsel, C., Parchmann, I., Ralle, B. (**2008**). Chemie im Kontext. Von der Innovation zur nachhaltigen Verbreitung eines Unterrichtskonzepts. Waxmann, Münster. [4] Sjoberg, S., Schreiner, C. (**2005**). How do learners in different cultures relate to science and technology? Results and perspectives from the project ROSE (the Relevance of Science Education). *Asia-Pacific Forum on Science Learning and Teaching* **6**/2. [5] Chemisch-Geowissenschaftliche Fakultät (**2021**). Fachdidaktische Transferforschung. www.chemgeo.uni-jena.de/fakultaet/institute-und-forschungszentren/institut-fuer-anorganische-und-analytische-chemie/arbeitsgruppe-chemiedidaktik/forschung-ag-wilke/fachdidaktische-transferforschung [6] Karabulut, R., Sonmez, K., Turkyilmaz, Z., Bagbanci, B., Basaklar, A. C., Kale, N. (**2010**). An In Vitro and In Vivo Evaluation of Tensile Strength and Durability of Seven Suture Materials in Various pH and Different Conditions: An Experimental Study in Rats. *The Indian journal of surgery* **72**/5, 386–390. [7] Knutson, C. M., Schneiderman, D. K., Yu, M., Javner, C. H., Distefano, M. D., Wissinger, J. E. (**2017**). Polymeric Medical Sutures: An Exploration of Polymers and Green Chemistry. *J. Chem. Educ.* **94**/11, 1761–1765.

Elisabeth Dietel
Research Assistant
Friedrich Schiller University Jena
Chemistry Education Department
August-Bebel-Str. 2, D-07743 Jena
elisabeth.dietel@uni-jena.de

The authors would like to thank the DFG (project number 316213987, SFB 1278 „PolyTarget“, project Ö01) and Prof. Dr. Falk Rauchfuß (University Clinic Jena) for support in the development of the experimental series.

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