

**Experimental study of physical
properties of artificial materials for the
development of valvular heart
apparatus in comparison with
biological analogs**

Aleksandra Chiryatyeva
Research Institute of Circulation Pathology,
Novosibirsk, Russia
2017

Outline

- Background
- Materials
- Methods
- Results and discussion
- Conclusions

Heart valve replacement

```
graph TD; A[Heart valve replacement] --> B[Bioprostheses]; A --> C[Artificial materials]; B --> D[Xenopericardium]; C --> E["Polytetrafluoroethylene (PTFE)"]
```

A hierarchical flowchart starting with 'Heart valve replacement' at the top. A horizontal line below it branches into two vertical lines leading to 'Bioprostheses' on the left and 'Artificial materials' on the right. From 'Bioprostheses', a vertical line leads down to 'Xenopericardium'. From 'Artificial materials', a vertical line leads down to 'Polytetrafluoroethylene (PTFE)'.

Bioprostheses

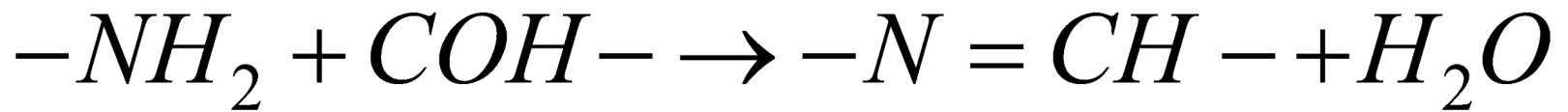
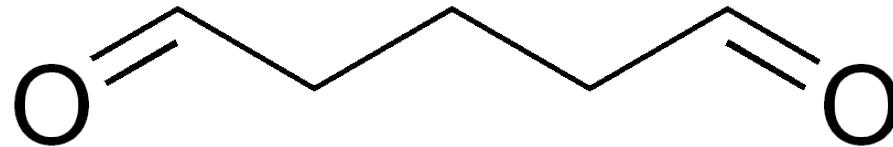
Xenopericardium

Artificial materials

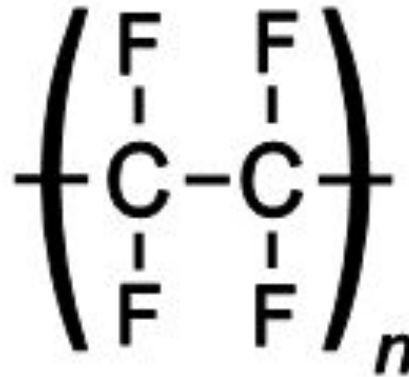
Polytetrafluoroethylene
(PTFE)

Pericardium

- Natural porcine tissue
- Chemically treated by 0.6% glutaraldehyde

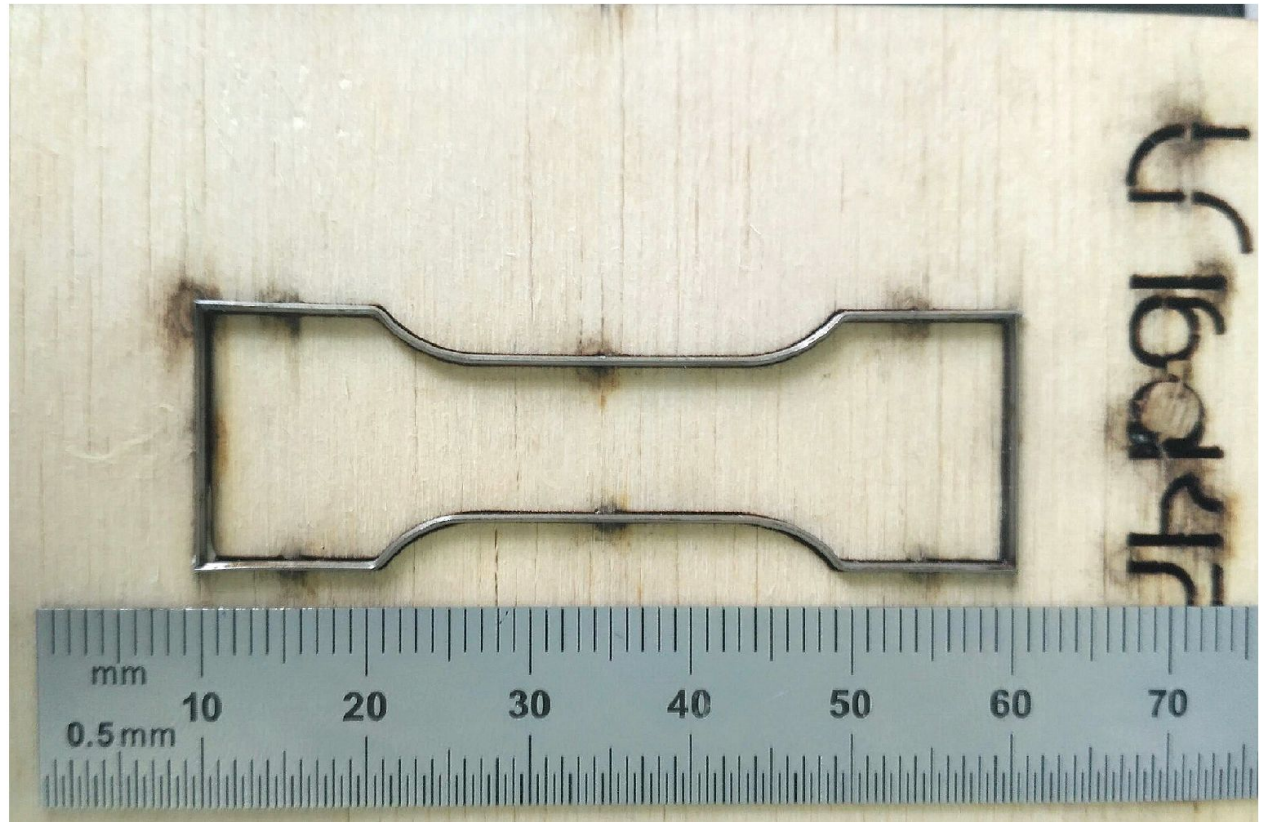
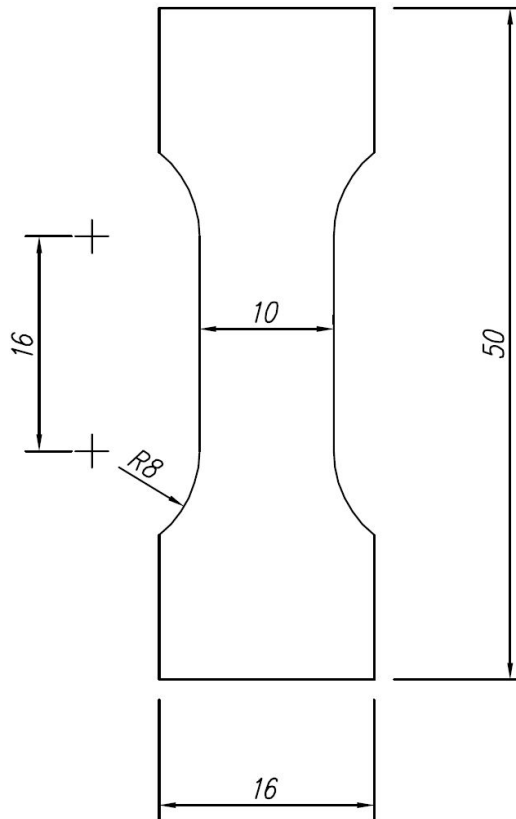


Polytetrafluoroethylene (PTFE)

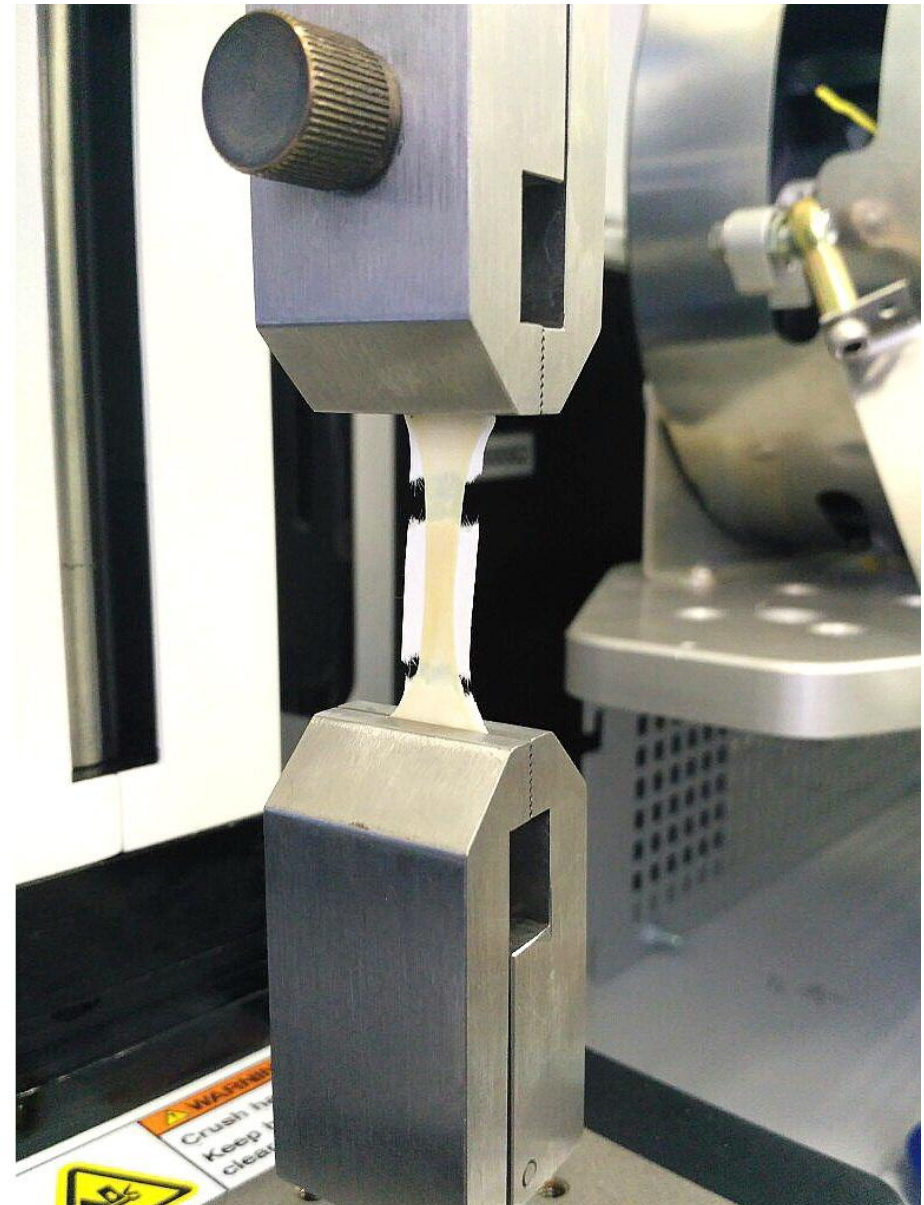
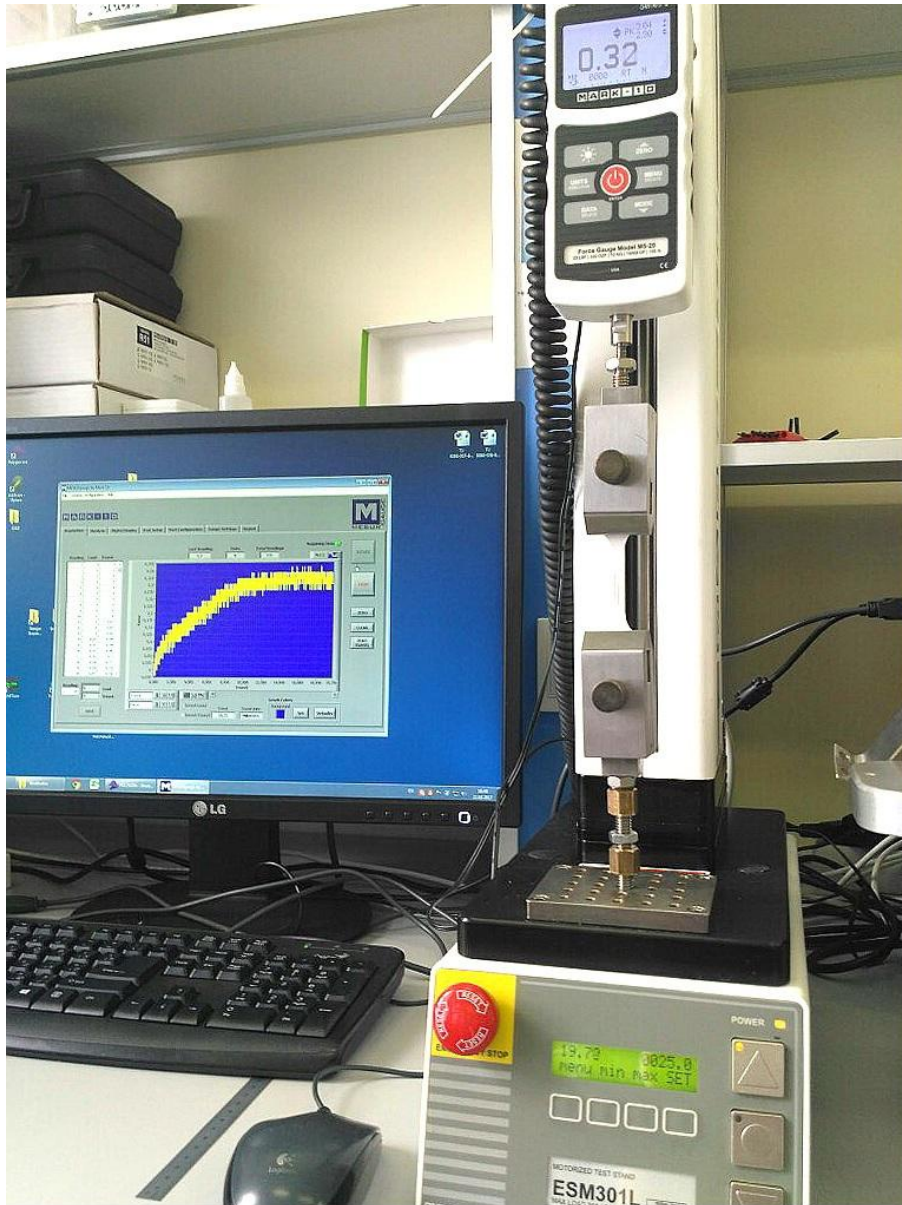


- Expanded – more porous and flexible
- Hydrophobic and chemically inert

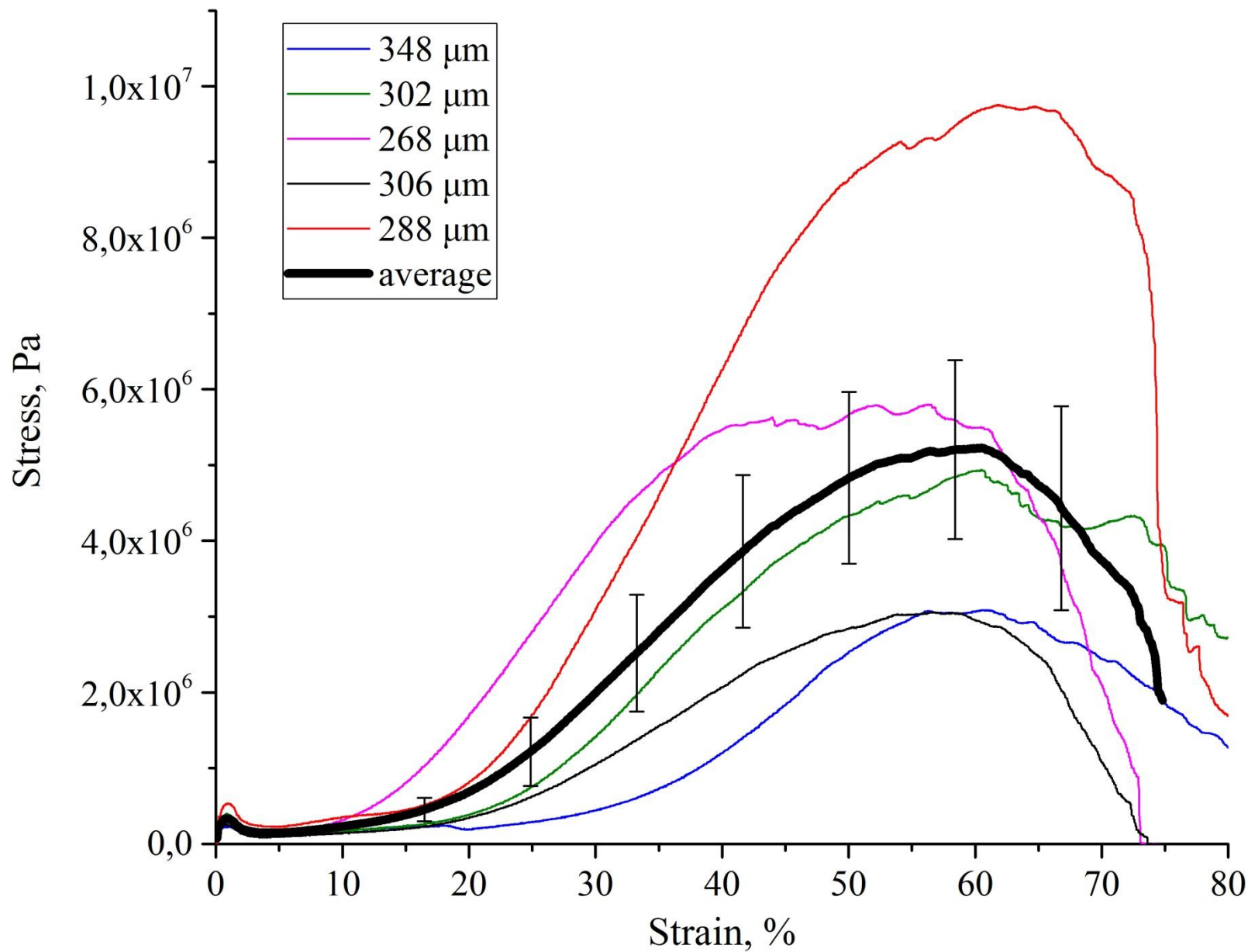
Blanking die



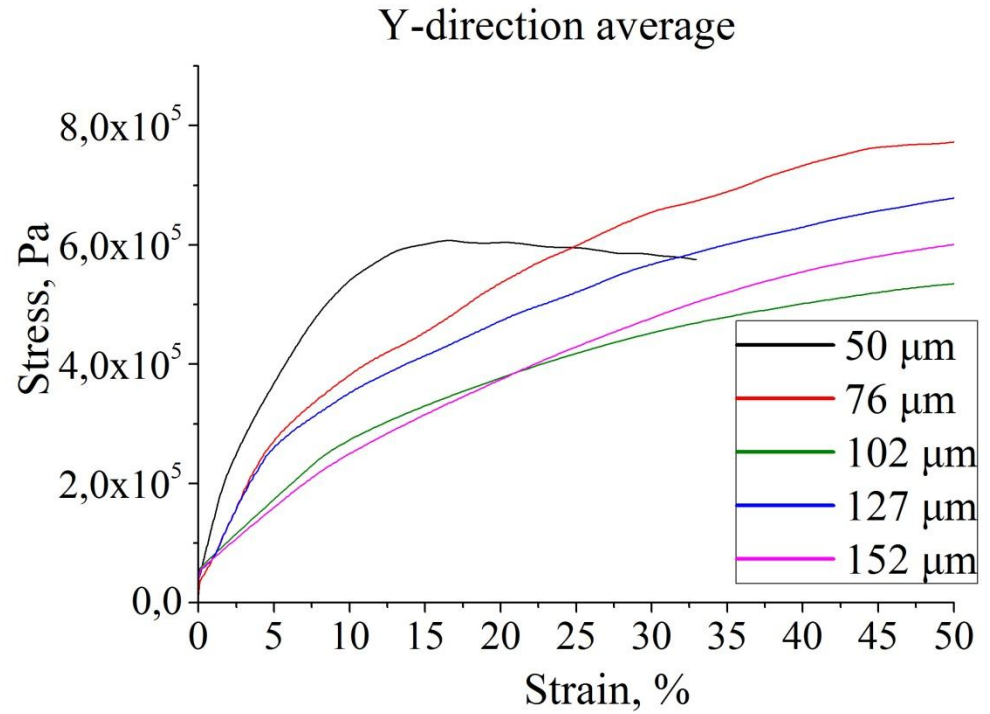
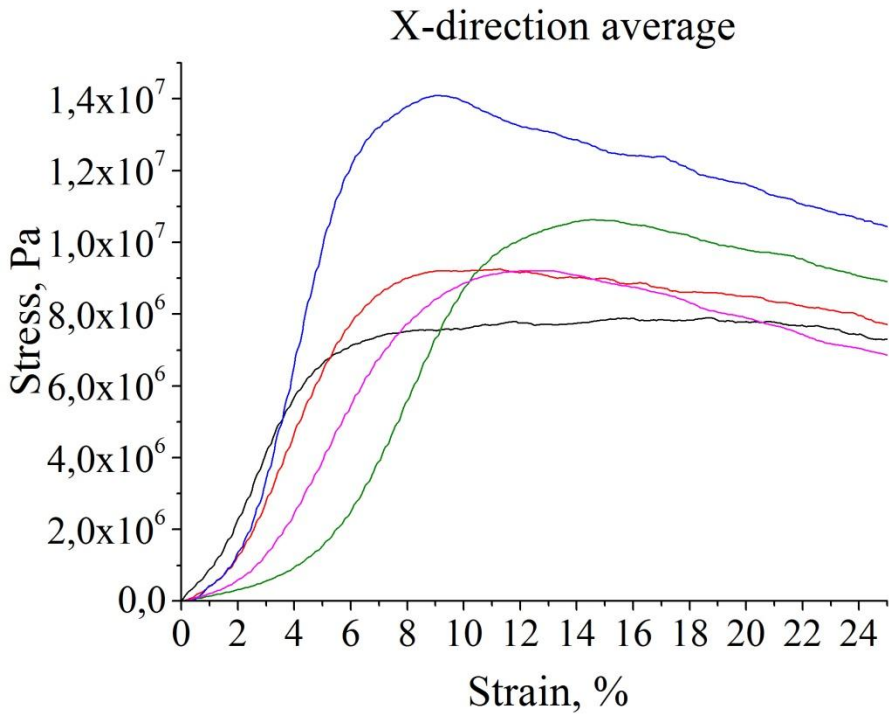
Motorized test stand



Pericardium tensile test



ePTFE tensile test



Results

Pericardium

- $E=1.52$ MPa
- $UTS=5.22$ MPa
- Elongation at breakpoint is 60.4%

ePTFE

- $E>15$ MPa
- $UTS=9.2\div 11.3$ MPa
- Elongation at breakpoint is 8-14%

Conclusions

- The elastic modulus of ePTFE samples is significantly higher than that in pericardial samples
- The form of stress-strain curves of ePTFE depends on the stretching direction
- The next step: enhancement of quality of ePTFE sheet
- Test other polymeric materials

References

- Mendis S., Puska P., Norrving B. Global atlas on cardiovascular disease prevention and control. World Health Organization in collaboration with the World Heart Federation and the World Stroke Organization. pp. 3–18 (2011)
- Aguiari P., Fiorese M., Iop L., Gerosa G., Bagno A. Mechanical testing of pericardium for manufacturing prosthetic heart valves. *Interactive CardioVascular and Thoracic Surgery* 22, pp. 72–84 (2016)
- Schoen F. J., Levy R.J. Tissue heart valves: Current challenges and future research perspectives. *J. Biomed. Mater. Res.*, 47: pp. 439–465 (1999)
- Zhang B., et al. Transcatheter pulmonary valve replacement by hybrid approach using a novel polymeric prosthetic heart valve: proof of concept in sheep. *PLOS ONE* 9(6) (2014)
- Sung H. W., Chang Y., Chiu C. T., Chen C. N., Liang H. C. Crosslinking characteristics and mechanical properties of a bovine pericardium fixed with a naturally occurring crosslinking agent. *J. Biomed. Mater. Res.* Nov 47(2): pp. 116-26 (1999)
- Landau L. D., Lifshitz E. M. *Theory of Elasticity*. Vol. 7 (3rd ed.). Butterworth-Heinemann. (1986)