CO-EXTRUSION

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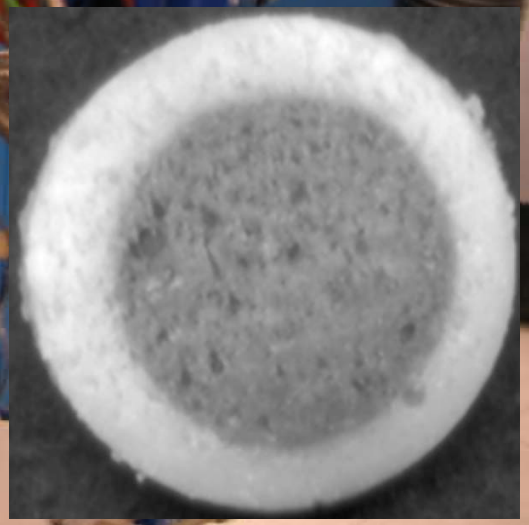
TNO | Knowledge for business



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TNO Defence, Security and Safety

Reorganization to better meet Government and Market needs

TNO-DSS = TNO-PML + 2 other TNO institutes

Contractors:
- Foreign and Dutch governments
- Defence or safety related industries

TNO Defence, Security and Safety

Business Units:

1- Observation systems
2- Information & operations
3- Protection, munitions and weapons
4- Biological and chemical protection
5- Behavior, training and performance

BU3: protection, munitions and weapons

Departments:

1- System performance and survivability
2- Explosives and ballistic protection
3- Energetic materials
4- Electrical power technology

Energetic materials

Research topics related to gun propellants:

- Development of new gun propellants
- Charge designs
- Prototypes for 35 mm up to 176 mm caliber guns

Goal: increased performance and safety

Uses for co-extrusion

Better performance of the gun propellant:

- Better ignitable LOVA propellants
- Less gun barrel erosion
- Increased progressivity

Theory

co-extrusion quality aspects

- Interlayer instabilities
- Viscous encapsulation
- Elastic rearrangement

- Yield stress
- Slip at wall- and bonding surface

References:

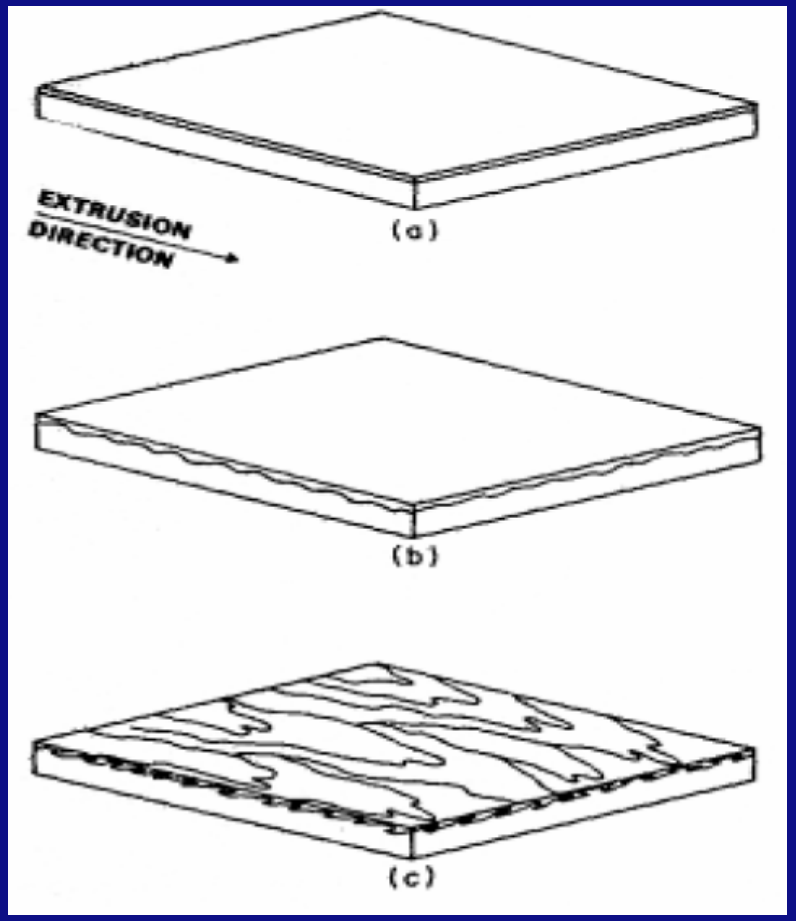
• Dooley, University of Eindhoven, 2002

• HFMI
• NSWC IHDIV
• ARDEC

Theory

Interlayer instabilities

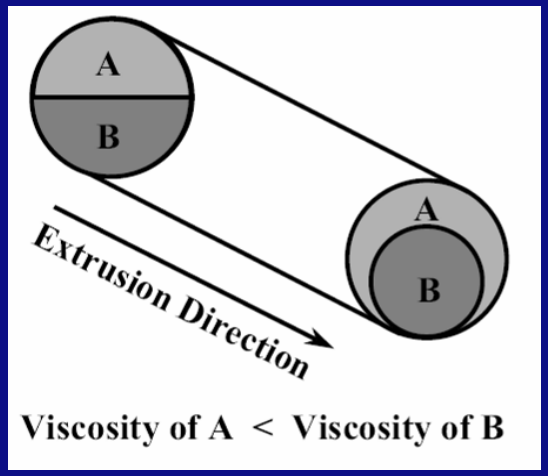
- Good layer
- Interlayer instability
- Interlayer instability

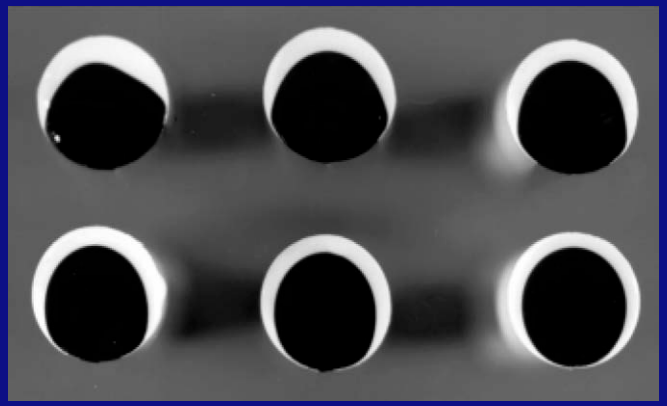


Theory
Viscous encapsulation

Ratio between viscosity B/A = 2.5

- The higher the ratio, the better the encapsulation
- The longer the die, the better the encapsulation





Theory
Elastic effects

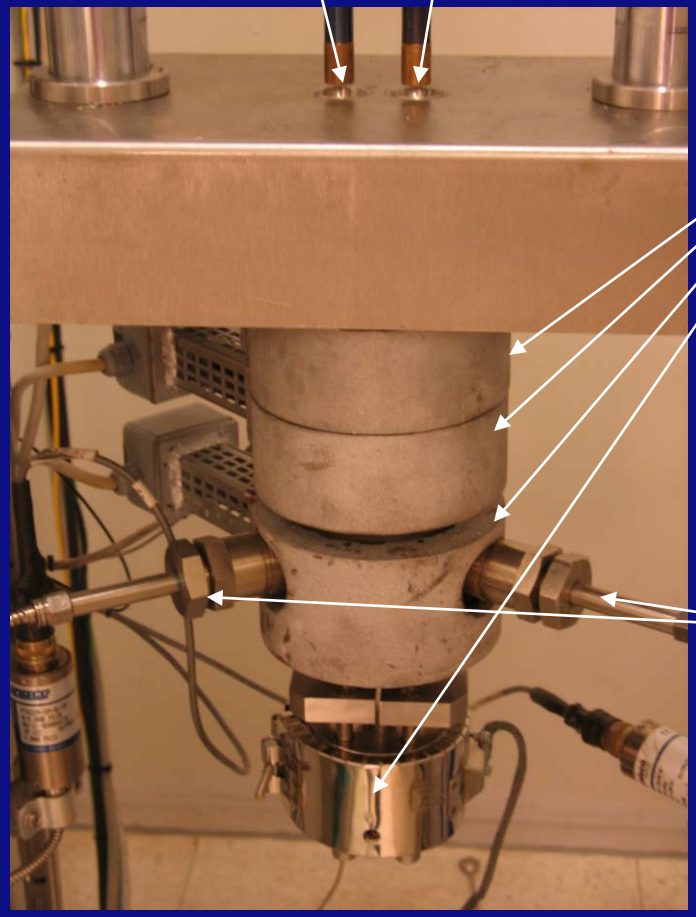
- Rearrangement of the layers by elastic effects

Entry of the square channel

Flow along the channel

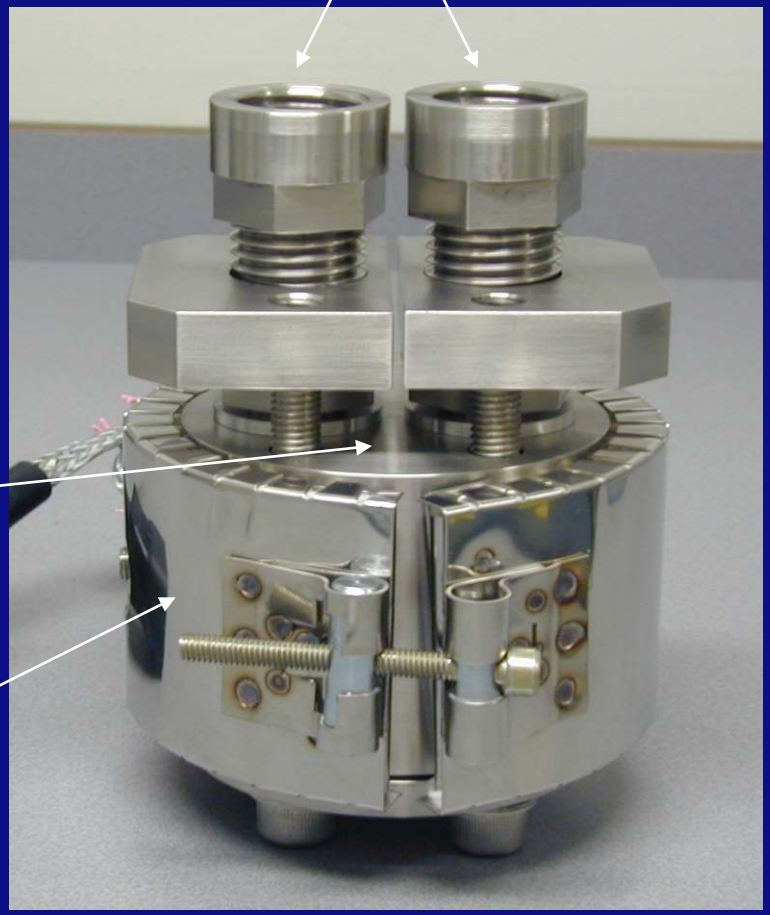
Experimental setup

Small scale



Experimental setup

Co-extrusion die system



Experimental results

Viscous encapsulation

Various parameters:

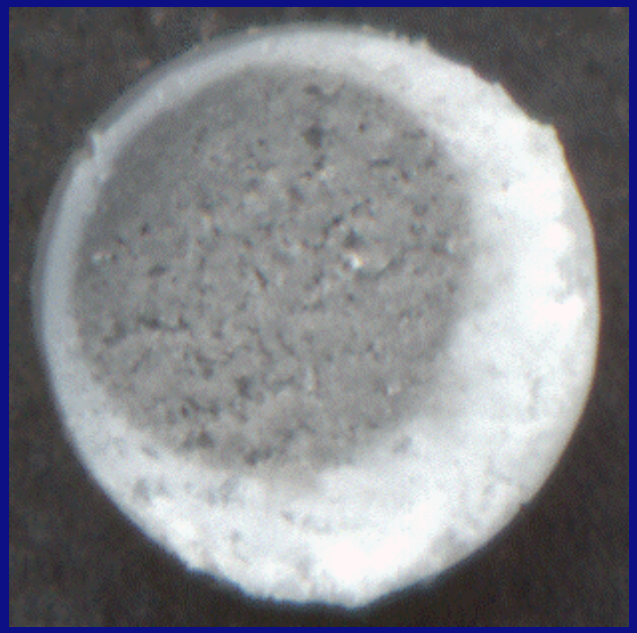
- Throughput
- Temperatures
- Viscosity ratio

Viscosity ratio between black and white layer = 2.5

Viscosity ratio = 1

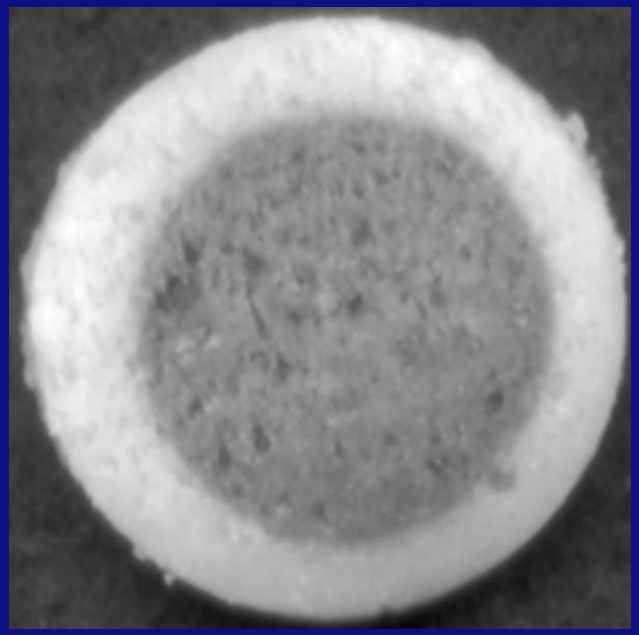
Experimental results

Different die-design



-Viscosity ratio = 1

-Same material



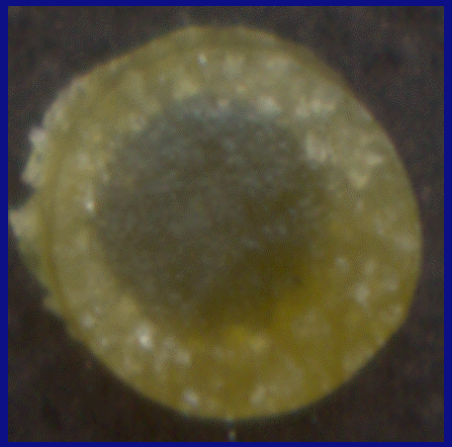
-Viscosity ratio = 1

-Same material

Experimental results
Different materials

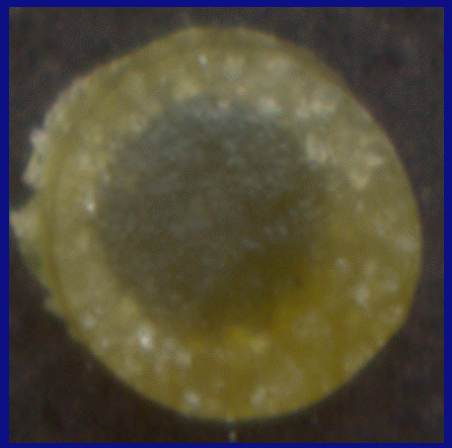
- 2 different materials cause slip

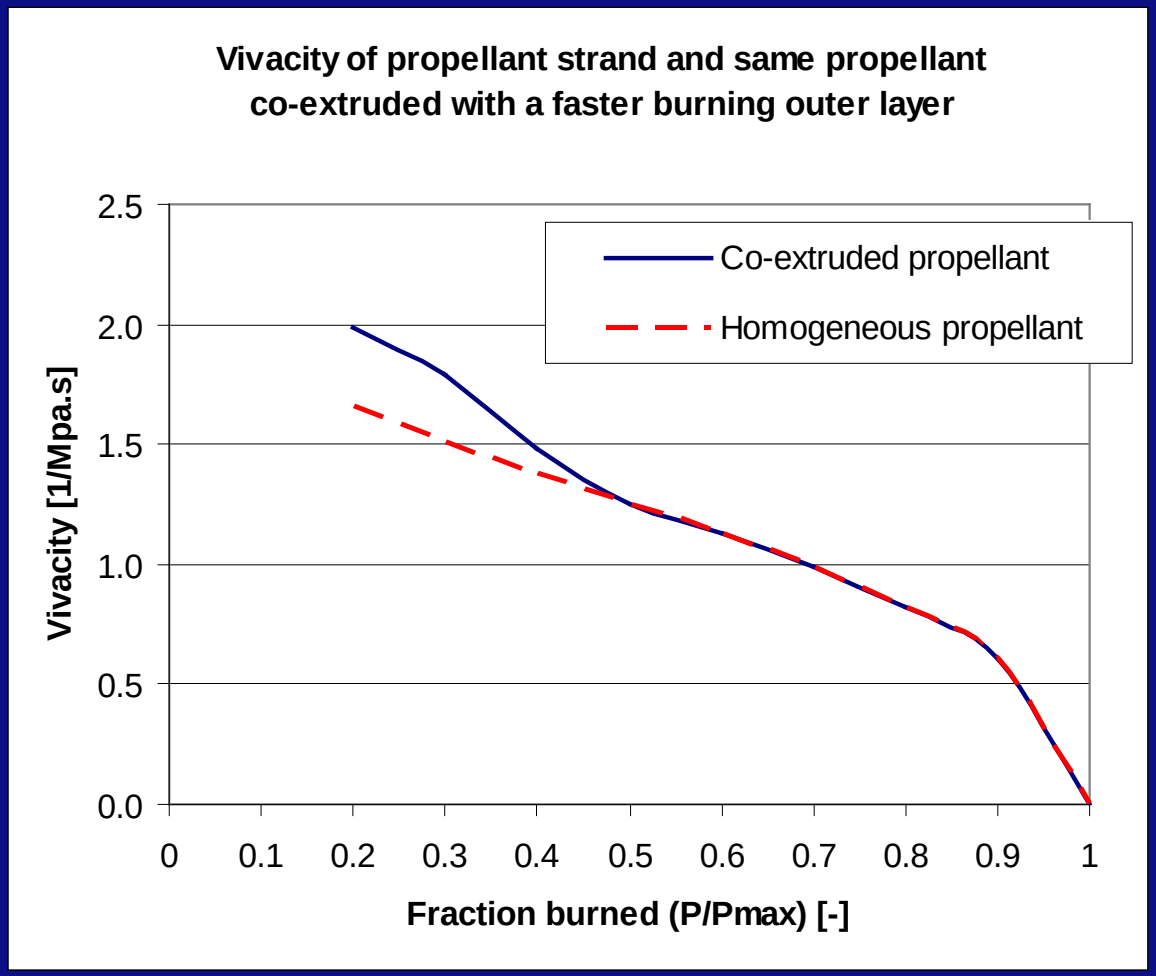
- Acceptable co-extrusion between 2 different materials



Experimental results

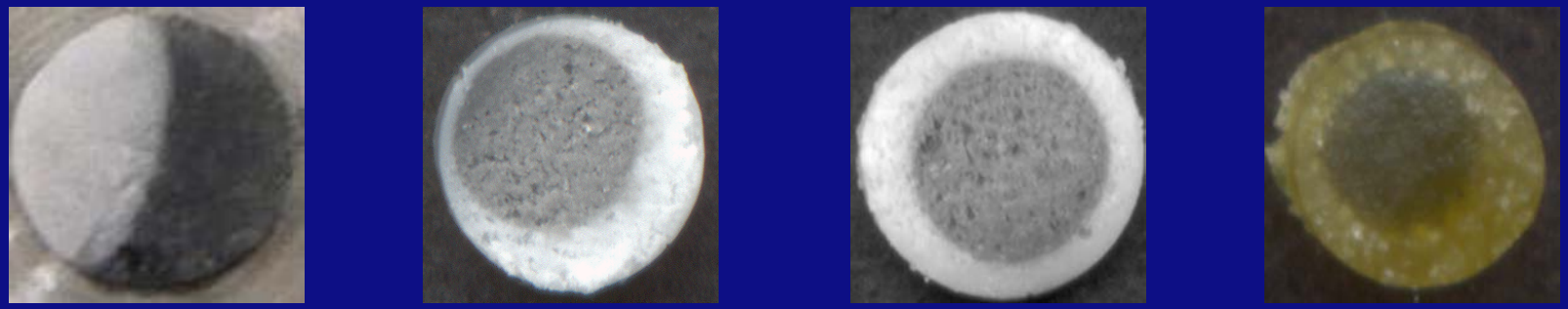
Burning of co-extruded and normal gun propellant strands





Conclusions

- There is no need to have a viscosity ratio higher than 1
- TNO can create co-extruded strands successfully :



From left to right: development of a good co-extrusion strand

Future research

- Design dies with different shapes
- Elastic reorientation - small scale experiments
- Large scale co-extrusion with 2 extruders
- Collaborate with interested parties