Evaluating mechanical properties of Paroxetine-loaded filaments to enable printability by fused deposition modelling

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INTRODUCTION

Three-dimensional printing (3DP) has been recently identified as an opportunity to make a significant technological leap over traditional pharmaceutical manufacturing processes, namely regarding customization of medicines.

Fused deposition modelling (FDM), the most commonly used 3DP technique, involves the manufacture of a drug-loaded filament, obtained previously by **hot-melt extrusion (HME)**, which is then melted and continuously deposited on a surface, layer by layer, building the 3D-printed dosage form [1].

The **successful integration of HME and FDM** requires that both extrudability of the raw materials and printability of the HME filaments fabricated are attained, properties which are influenced by the mechanical, rheological and thermal properties of materials [2-4].

AIM Evaluate the **impact of the environmental conditions** on the **quality and printability** of **Paroxetine-loaded** polymeric formulations for **integrated HME-FDM**.

Formulation | Storage Conditions | Processing Setup

Rheological Thermal Properties → **Printability of filaments** / **Integration of HME and FDM** ← Mechanical Properties

MATERIALS & METHODS

Formulation: PRX (30% w/w), HPC (54% w/w) and other excipients (16% w/w of a mixture made of CaP, MS and TEC in a 10:1:5 ratio)

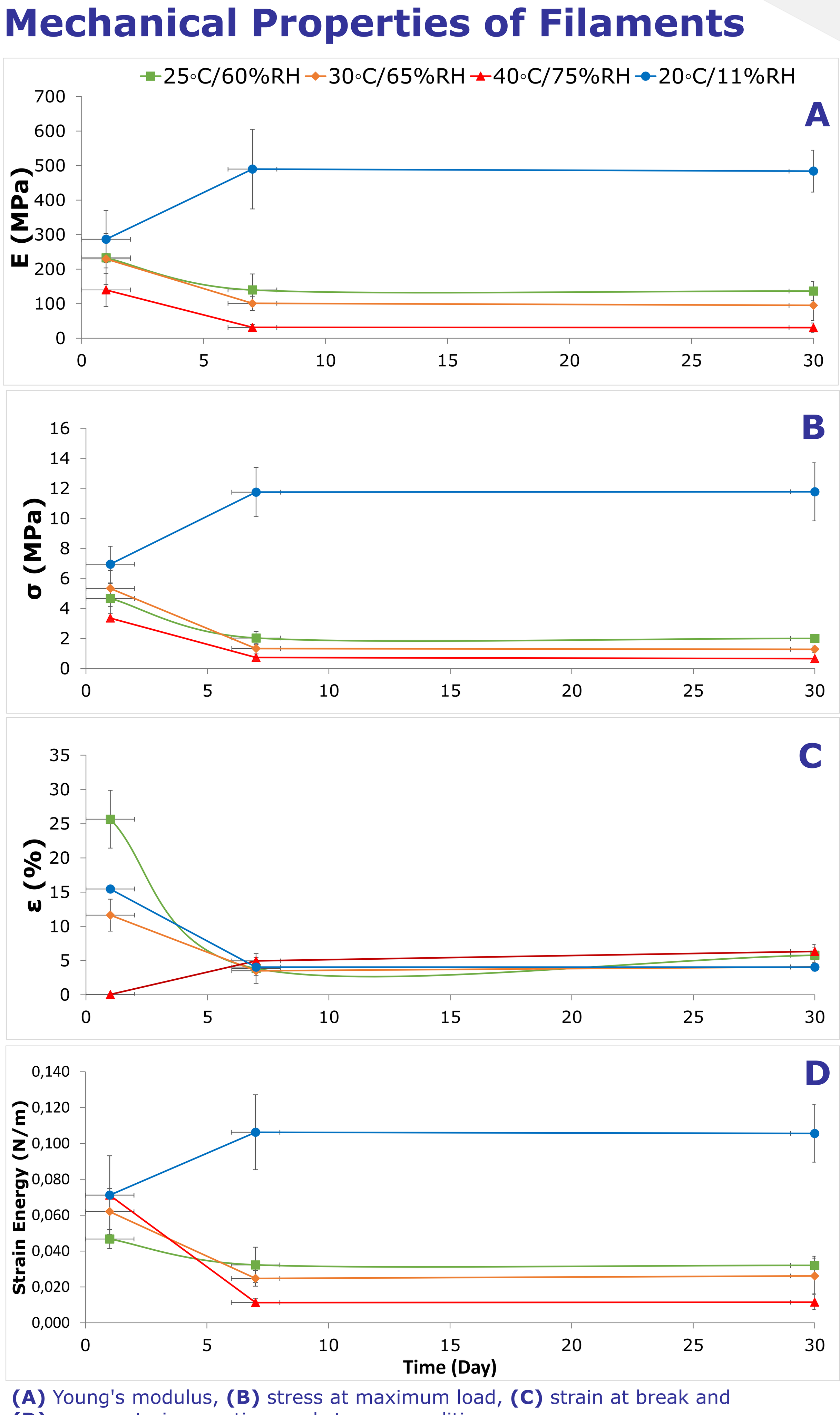
Preparation of Filaments: Filaments containing polymeric formulation were prepared by HME (Notzek Pro single screw extruder, Notzek)

Stability of Filaments: Filaments were stored in stability chambers (Fitoclima D1200PH, Aralab) and dessicator inside open plastic bags, and re-examined at pre-defined times.

Evaluation of Filaments: Mechanical properties, moisture content and feeding/printing performance of filaments were evaluated for the different time points and conditions of storage.

3DP – **Printing of 3D tablets**: Whenever possible, FDM 3D-printed tablets were manufactured (3D printer Delta WASP 20 40 Turbo 2, Wasp, Italy)

Mechanical Properties of Filaments



(A) Young's modulus, **(B)** stress at maximum load, **(C)** strain at break and **(D)** energy strain over time and storage conditions.

RESULTS & DISCUSSION

High Humidity (>60%RH)

- ↑ Water content
- ↑ Plasticization of filaments
- ↑ Breakage with significant deformation
- ↓ Stiffness and stress at maximum load
- ↓ Stress at break and energy strain

Filaments **were not** printable

Highly ductile filaments with remarkable flexibility

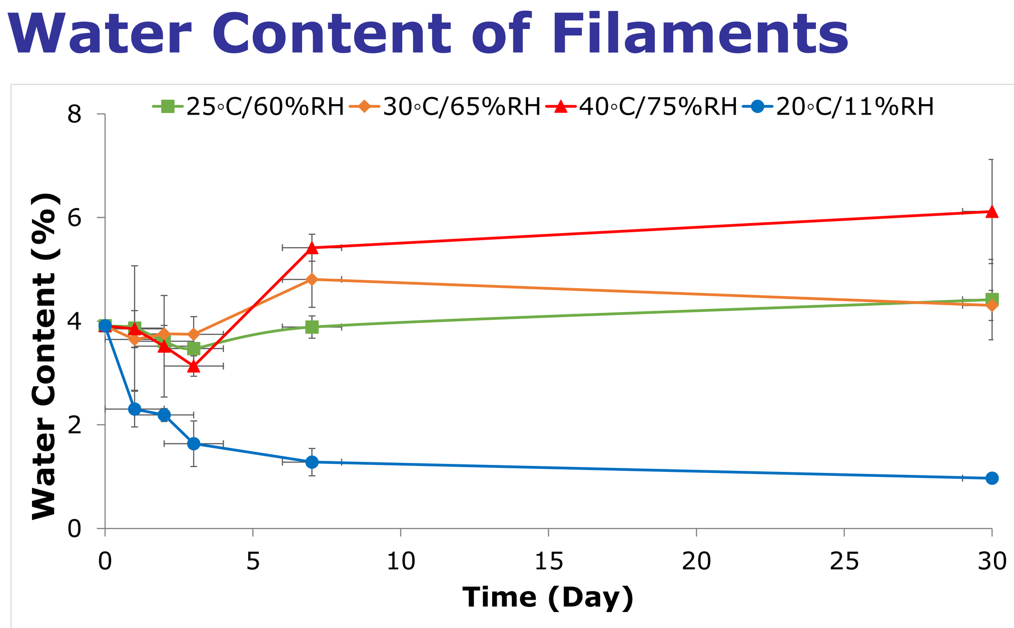
Low Humidity (11%RH)

- ↓ Water content
- ↓ Plasticization of the filaments
- ↑ Breakage with low deformation
- ↑ Stiffness and stress at maximum load
- ↑ Energy strain at break

Filaments **were** printable

Filaments with adequate ductility and stiffness

Water Content of Filaments



40°C/75%RH > 30°C/65%RH > 25°C/60%RH >> 20°C/11%RH

Printability of Filaments

Stability Conditions (Temp./Humidity)	Time (Day) 0	1	7	30
20°C/11%RH	No	Yes*	Yes*	Yes*
25°C/60%RH	No	No	No	No
30°C/65%RH	No	No	No	No
40°C/75%RH	No	No	No	No

*Printing temperatures of 200°C (extrusion) /50°C (plate) were used when the 3DP process was successful.

CONCLUSION

This work reinforces the **importance of the mechanical properties of PRX-loaded filaments in their processability**, and correlates these factors to environmental conditions (moisture content).

This type of study is crucial to **optimize the manufacturing process** and to **anticipate the most satisfactory storage conditions** for these materials.

Complementary studies to speed up the printability of filaments should be explored.

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