Investigation of Polymer Functional Groups and their Impact on Sperm Viability

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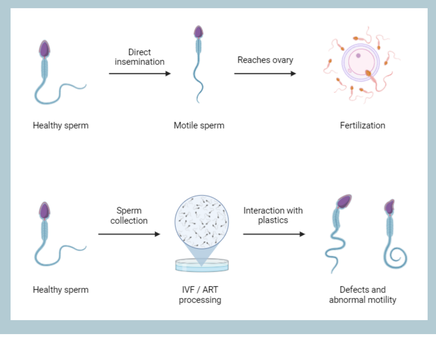
Introduction

- Male infertility contributes to ~50% of cases needing reproductive technology assistance.
- Lab plastics are widely used, yet their impact on sperm health is largely unknown.
- Plastics and their functional groups may impair sperm motility.
- Production processes introduce toxic compounds that could reduce sperm motility.
- The purpose of this project is to investigate how plastic lab materials affect sperm motility.



Materials & Methods

Materials:

1. Centrifuge tube
2. Cryogenic vial
3. Petri dish
4. Specimen collection containers
5. Syringes
6. Microfluidic racetrack

Bioassay motility tests:

- Expose semen samples to all material types
- Count motility at hour 0, within hour 7, and within hour 26 of exposure
- Progressive motility (PM), nonprogressive motility (NPM), and nonmotile (NM) recorded

Material characterization:

- SEM/EDS was used to image and determine potential contaminants present
- FT-IR was used to determine the functional groups present

Microfluidic device:

- The microfluidic device was fabricated using PDMS to create vacuum and fluid channel
- A counterflow was ran with HTF + 1% BSA at 0.092 µL/min with 2.2 µL of semen sample for 30 minutes
- The second test exposed the semen sample to a syringe for 30 minutes before repeating the racetrack test
- Motility for each segment between ports were analyzed

Bioassay Results

Specimen Collection Cups:

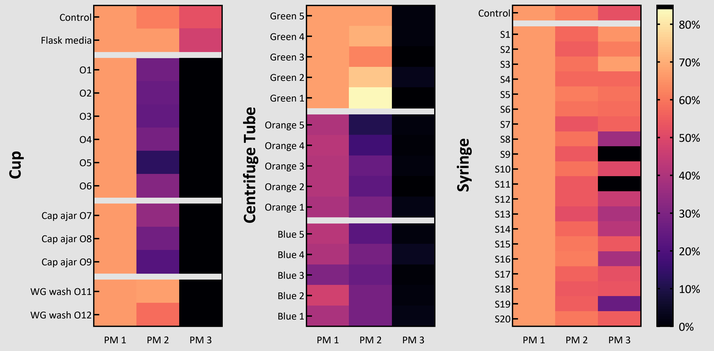
- Off-gassing did not maintain motility, but media washing improved motility retention compared to untreated cups.

Centrifuge Tubes:

- Blue and Orange tubes showed significant decrease in motility versus Green tubes.

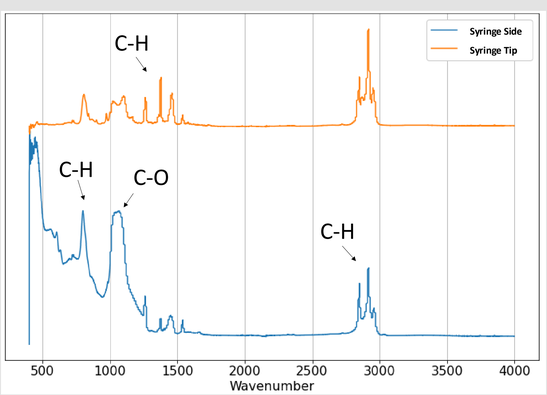
Syringes:

- 40% of syringes showed abnormal decline in motility when compared to the control sample.
- 10% of syringes caused complete motility loss, indicating cytotoxic effects.



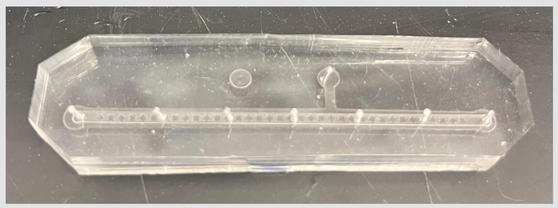
FTIR & SEM Characterization Results

The chart shows every element found within each lab plastic used. Al was prevalent within every sample. The syringe showed both the side material and tip to contain the most contaminants.

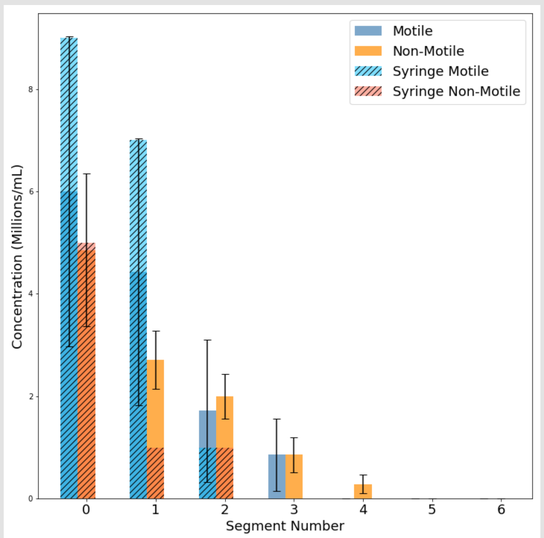


The graph above shows the results of the syringe side and tip. The side of the syringe contains peaks similar to most of the lab materials used. However, the tip is a unique material unlike any other samples.

Microfluidic Racetrack



The microfluidic racetrack above has 6 segments excluding waste and HTF entrance that were utilized in the experiment.



Motile and non-motile sperm cells were recorded and averaged. The graph shows a sample test exposing sperm cells to the syringe for 30 minutes. The initial concentration was higher at the waste port, and decreased dramatically as the segments went on compared to the average unexposed tests.

Conclusions

Bioassay:

- Syringes showed 6.25-10% to be cytotoxic to sperm.
- Specimen containers showed off-gassing to be unhelpful but washing aided in maintaining motility.
- Centrifuge tubes impacted motility in all samples except green tubes showed normal motility impacts.

Characterization:

- Syringes showed the most contaminants including Al, Ti, Si, & Ba which can cause oxidative stress to sperm cells.
- Centrifuge tubes showed to contain Al, and Ti contaminants. Additionally, K, Ca, Na, & Cl which can negatively impact sperm motility if concentrations are unbalanced.
- The specimen cups showed Al, Ti, and Hf to be the main contaminants to potentially cause the motility decline seen in the bioassay tests.

Racetrack:

- The average motility within each segment tapers off suggesting the design works to separate the sperm cells.
- The syringe exposed test showed a decline in motility compared to unexposed samples, further suggesting syringes negatively impact sperm cells.

Recommendations

- Investigate long-term effects of plastics on human cells, focusing on cellular function and potential health risks
- Examine microplastic impacts on reproductive health, particularly sperm quality and genetic integrity
- Enhance microfluidic device capabilities for isolating and analyzing highly motile sperm
- Explore genetic factors contributing to superior sperm motility through genome sequencing of isolated populations
- Expand microfluidic applications to study environmental toxins and their effects on cellular health

These avenues of research aim to deepen our understanding of plastic-cell interactions and improve reproductive health technologies.

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