Evaluation of materials for suitability in the construction of solar-powered unmanned hot-air balloons

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Background

- What are “solar balloons”?
  - Hot air for lift (no LTA gases)
  - Solar energy heats envelope
  - Envelope heats air by contact
  - Heated air inside generates lift

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Advantages

- Inexpensive
  - Envelope material: plastic sheet
  - Tape to seal edges
  - Lift gas: air
    - Fan
    - Hair dryer
    - Sunlight

- Safety
  - No flammable gases
  - No high-pressure plumbing
  - No heavy tanks
- Reusability
  - Tethered
  - Free flights?

Disadvantages

- Lower lift per cubic foot
- Lower ascent rate
- Lower maximum altitude
- Need clear sky, bright sun
- Time and effort to build envelope vs. buy

History

- Many other groups building and flying
- Variety of applications
  - Imaging/mapping
  - Atmospheric Science
  - Toys/recreation

UND Solar Balloon Flights

- July 21, 2013 – First proof-of-concept
  - 3 m (10 foot) diameter
    - 16 black plastic trash bags, 33 gal, 0.7 mil
    - 1 roll (55 m) of 18 mm masking tape
  - No payload
  - No tracking

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- December 9, 2013 – Second proof-of-concept
  - 5 m (16 foot) diameter
    - 36 black plastic trash bags, 30 gal, 0.5 mil
    - 2 rolls 18 mm masking tape
    - Duct tape for nozzle
  - Radar reflector
    - Foam core
    - Aluminum foil
    - Approximately 1 pound (17.1 oz)

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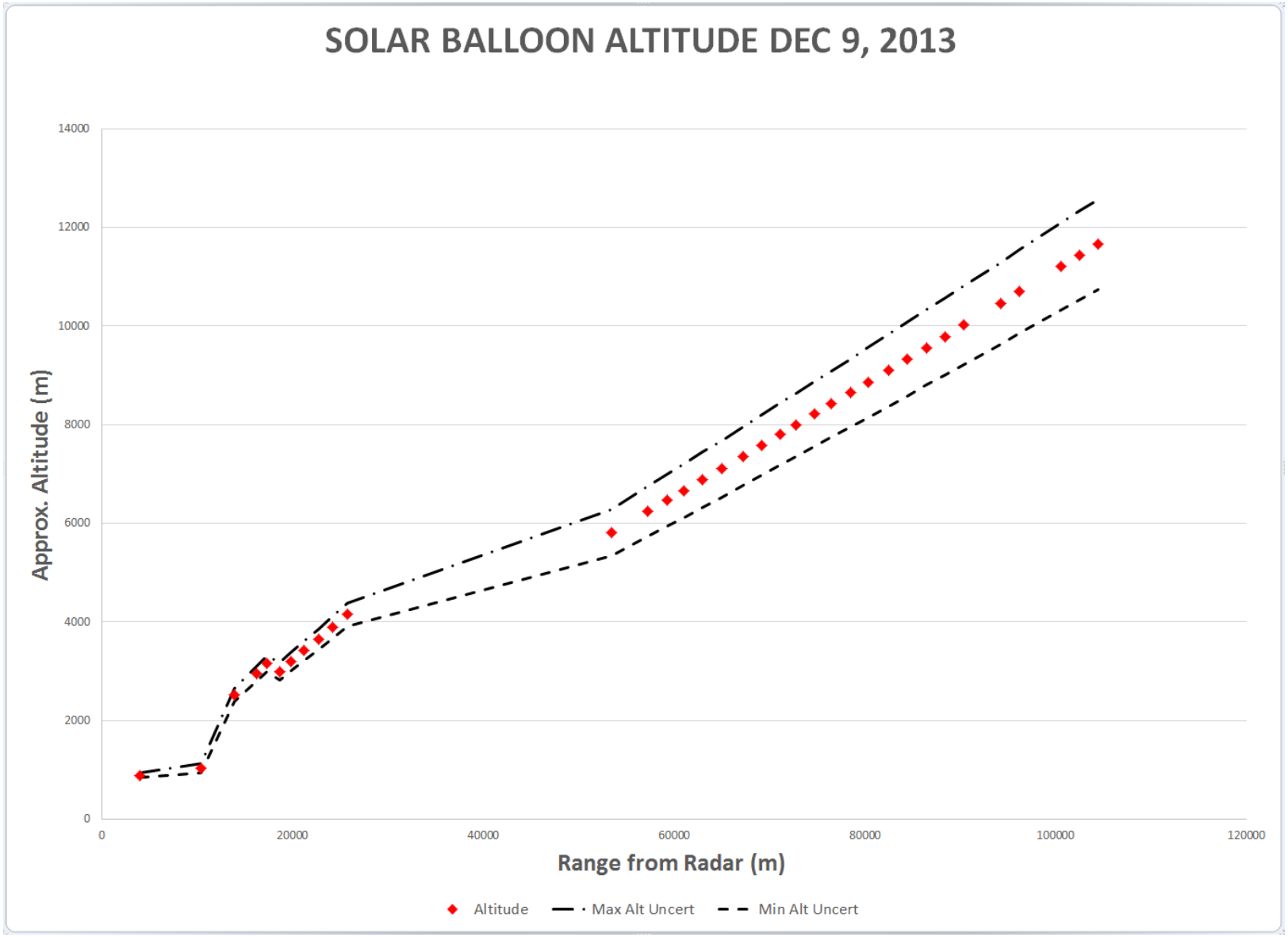

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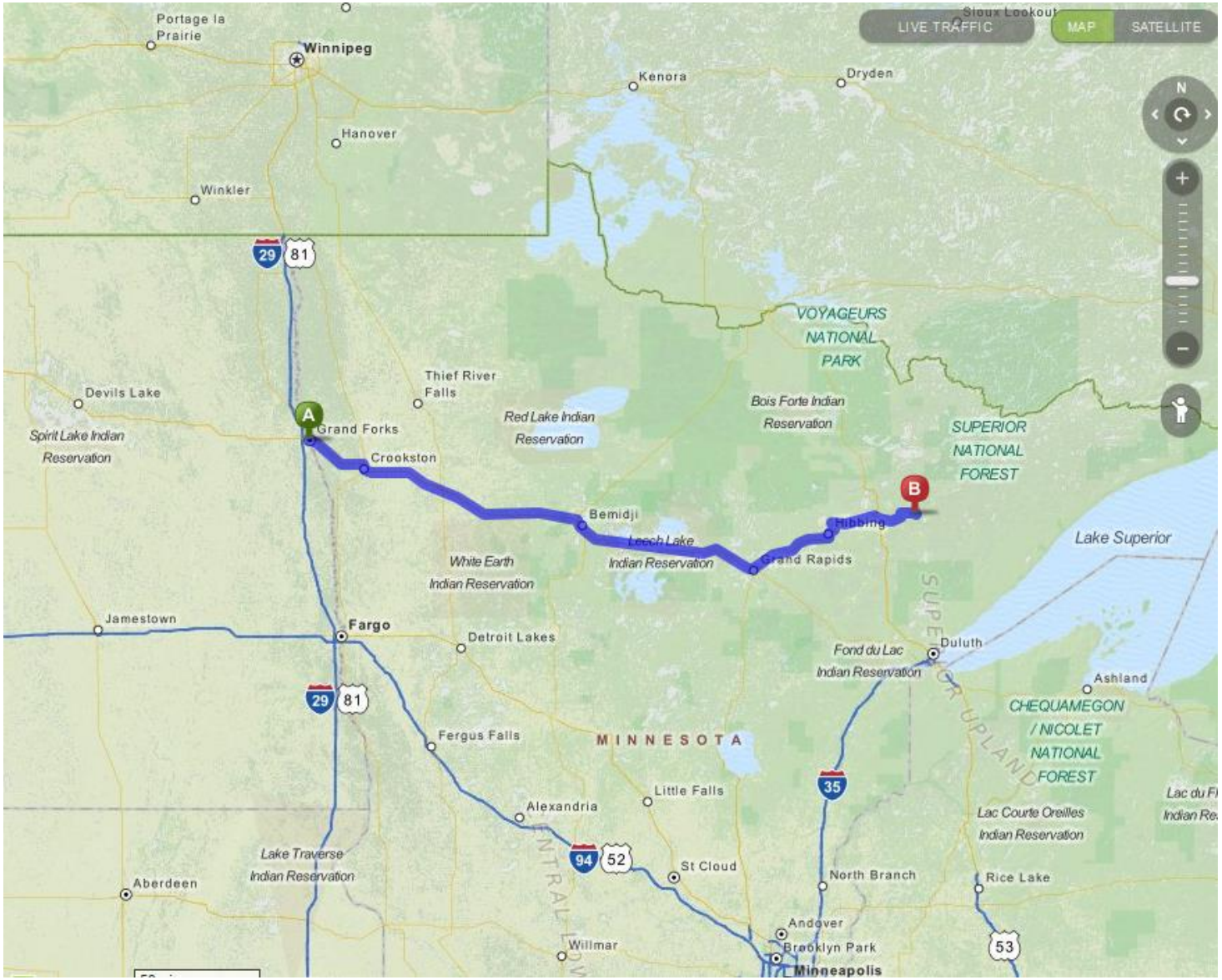

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What makes a good solar balloon?

- Efficient collection of solar energy
- Sufficient strength
- Low weight
- Easily available
- Low cost

What have others used?

- Black trash bags
- High density polyethylene sheeting
  - Clear
  - Pigment
    - Black paint pigment
    - Charcoal
    - Bone black
    - Tempra pigment

Our experiment

- How effective at solar heating?
  - Black trash bags
  - “Painters Plastic”
    - Printer toner powder
    - Untreated

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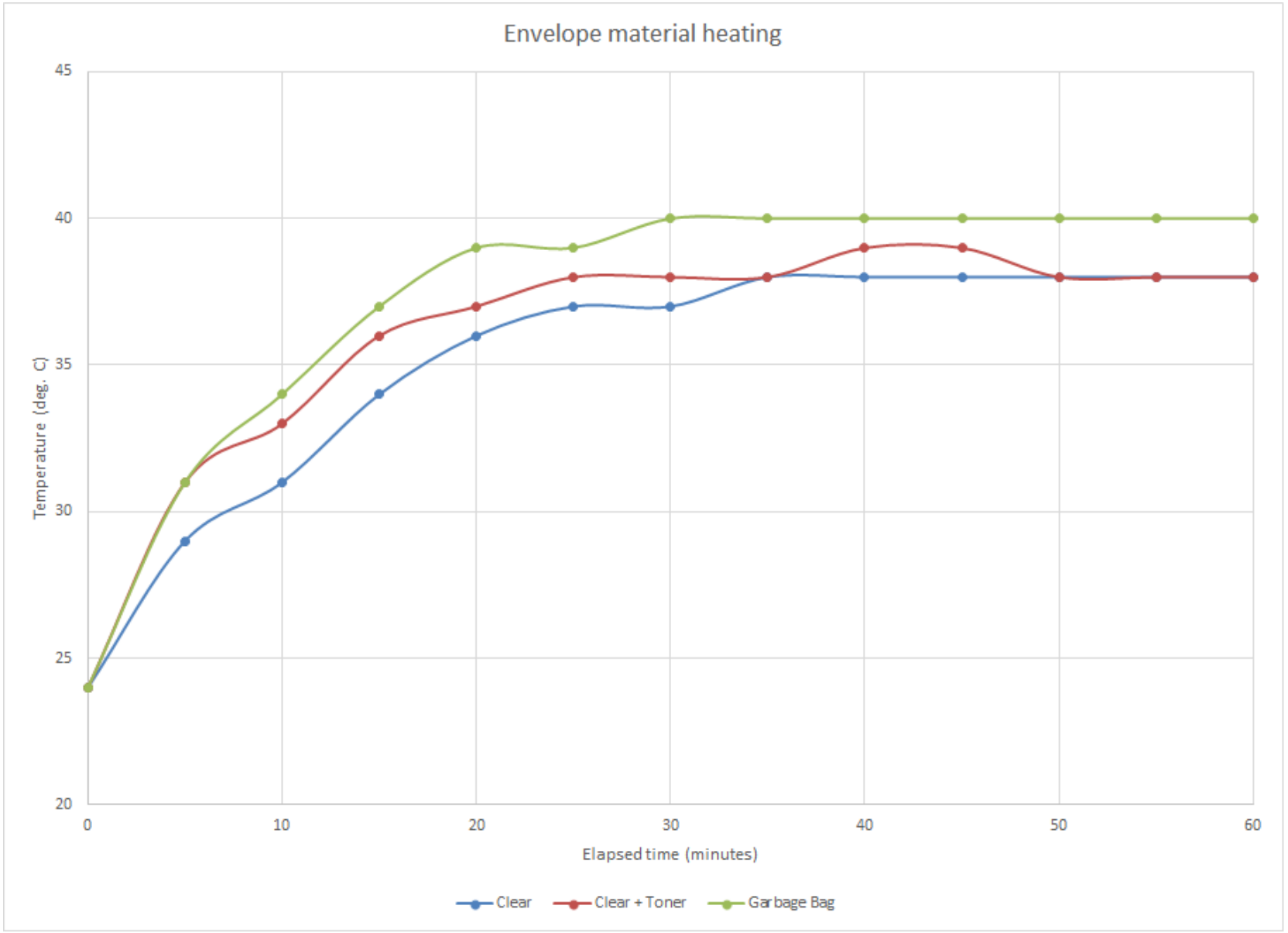
- Heating
  - Indoors (wind cooling, loosening tape)
  - Window filtering UV?
- Cooling
  - Clouds during flight
  - Sunset



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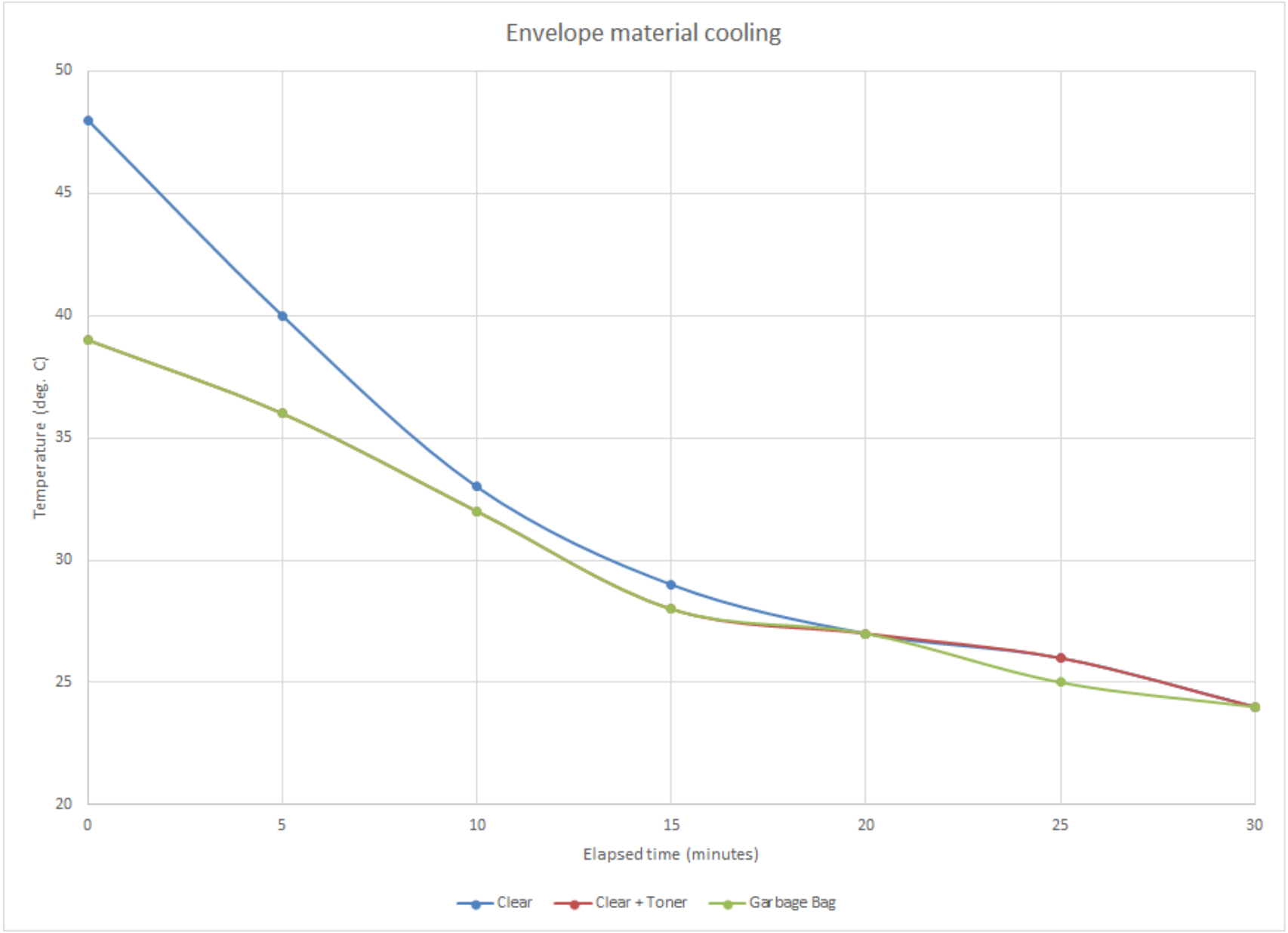

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Results

- Black plastic garbage bag material
  - Heated fastest
  - Reached highest steady-state temp
- PP with toner
  - Heated less quickly
  - Reached lower steady-state temp
- Untreated PP
  - Heated slowest
  - Steady-state equal to toner

Additional considerations

- Black garbage bags
  - Cheap, easily available
  - More effort to construct envelope
  - Mechanically weaker than PP
  - Better solar collector
  - Higher lift due to higher temperature air

- Painters Plastic
  - Cheap, easily available
  - Lower efficiency, both treated and untreated
  - Mess/hassle of adding pigment
  - Simpler to assemble (less cutting and taping)

Our preferred material

- Garbage bags
  - Best solar collector
  - Inexpensive
  - Easy to obtain
  - Easy to work with

Future Work

- Construct identical envelopes from each material for real-world lift testing
- Search for supplier of bulk black garbage bag plastic in 0.5 mil thickness
- Free flights to characterize flight capabilities
  - Lift vs. volume
  - Max altitude
  - Ascent rate

- Flight termination
  - Retaining envelope
  - Repair/reuse?

Questions?

References

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