PVC RESIN
(WBS 2.4.1.2)

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Anna Pla-Dalmau

PVC: CHEMISTRY

- Vinyl chloride is polymerized in water to yield PVC:
  - n CH_2=CHCl → -(CH_2-CHCl)$_n$- ↓ (insoluble)

- Pure PVC degrades easily
  - Sensitive polymer: T>100 °C, UV or γ-rays
  - -(CH_2-CHCl)$_n$- → -(CH=CH)$_n$- + n HCl
  - HCl and O_2 accelerate decomposition
  - Formation of C=C bonds results in yellowing of the polymer.

PVC: ADDITIVES

- PVC is a widely used plastic with applications from pipes (rigid) to toys (soft, plasticized).

- How is that possible? → additives
- PVC accepts a variety of additives that prevent degradation and make it processable:
  - Stabilizers, lubricants (different types), processing aids, impact modifiers, pigments, fillers, plasticizers…

PVC: PROPERTIES

- Rigid PVC:
  - Good chemical properties
  - Resistant to aliphatic hydrocarbons (**oils** and waxes)
  - Low water absorption
  - Molecular weight influences processing methods and end properties
    - K-value is related to molecular weight
    - Rigid PVC applications use a high K-value.

PVC: MANUFACTURERS

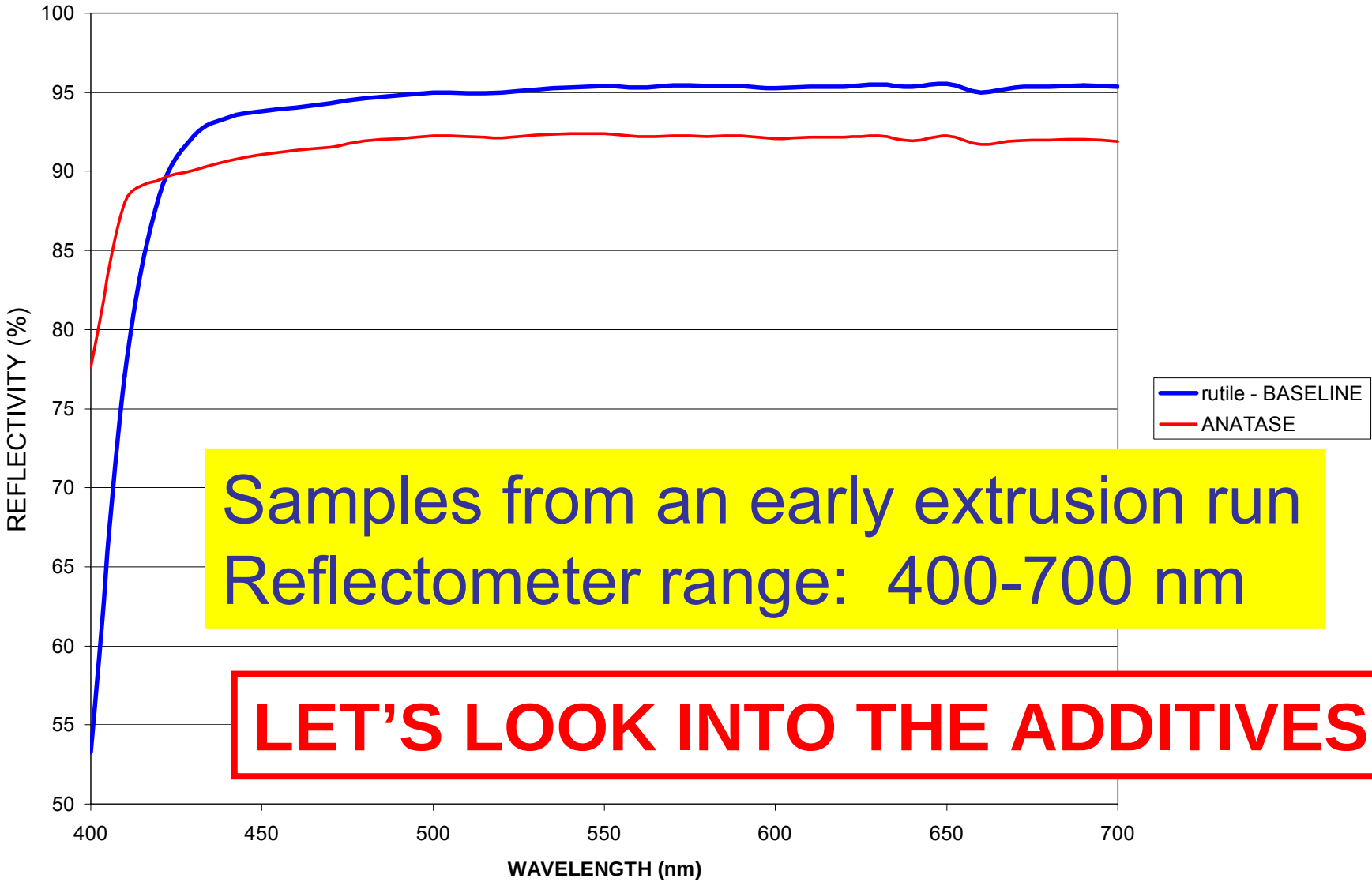
- PVC manufacturers:
  - Georgia Gulf, Shintech, PolyOne

- PVC formulators or compounders: take pure PVC polymer and add all the necessary components to meet the end-product requirements:
  - Aurora Plastics, Prime, Georgia Gulf, Clariant

PVC RESINS FOR NOVA

- For the NOVA extrusions, two properties to monitor:
  - Reflectivity spectrum:
    - White pigment – TiO2 – best performance
      - Rutile – (chlorine process)
      - Anatase – (sulfate process) better reflector at low wavelengths
    - ZnO, MgO degrade PVC – not tested by NOVA
  - Mechanical characteristics:
    - The result of all the additives present in the formula

PVC RESINS FOR NOVA



Samples from an early extrusion run
Reflectometer range: 400-700 nm

LET'S LOOK INTO THE ADDITIVES

PVC RESINS FOR NOVA

- Goal:
  - Try rutile and anatase; review all ingredients in formula
  - Test several formulations in small samples
  - Make and extrude ~ 4,000 lbs of the best candidates

- Initial PVC formulations prepared by:
  - James Summers, P3 Consultants

PVC RESINS FOR NOVA

- Final candidates were extruded in the large NOVA die.
- Tweak components to optimize resin for reflectivity and processability
- Extrusions were evaluated using a reflectometer (Fermilab and Indiana University) and light yield measurements using liquid scintillator and WLS fibers (Indiana University).
- ANATASE provided a higher light yield.

BEST NOVA PVC RESINS

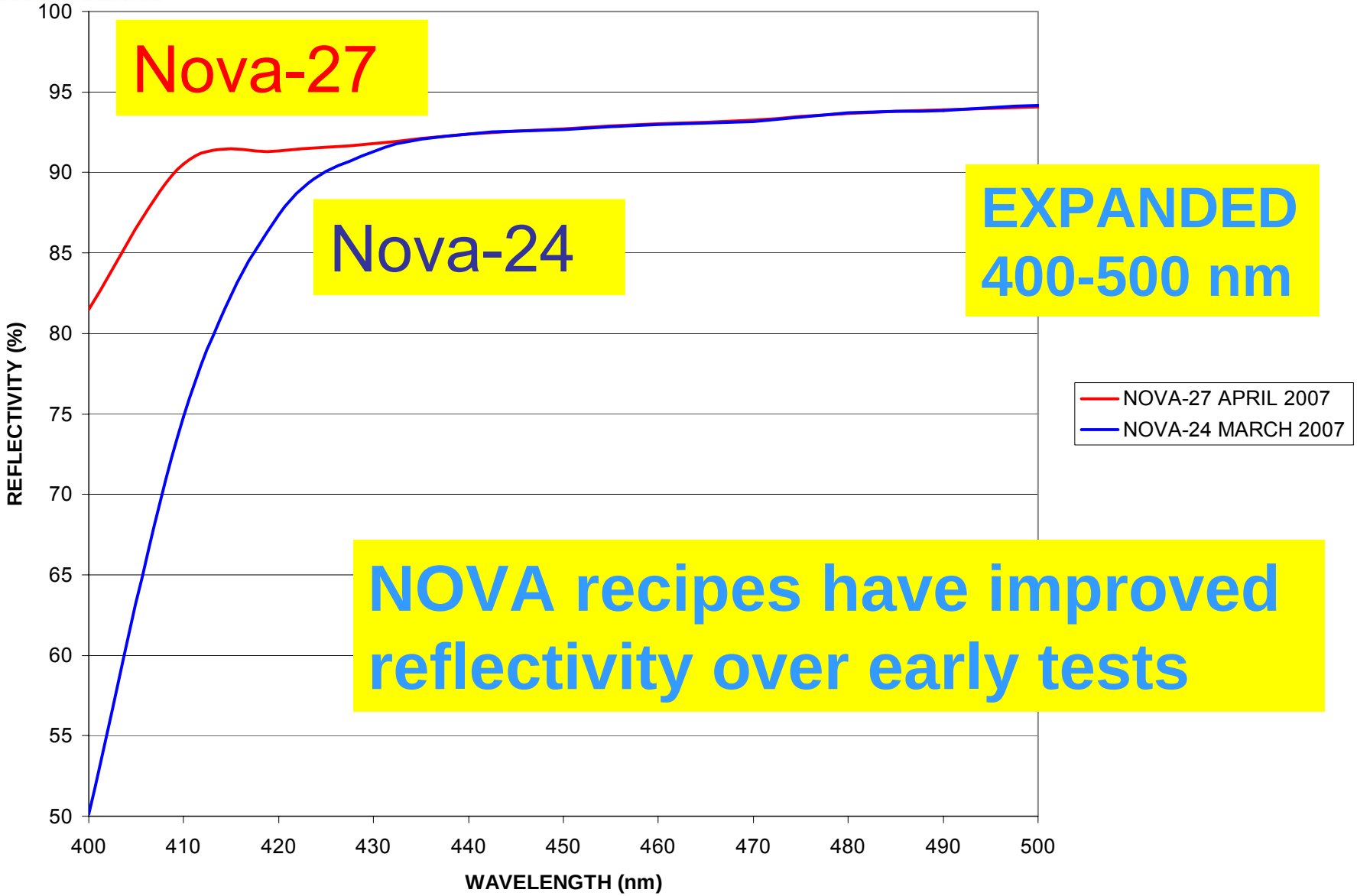
phr - per hundred parts of resin	NOVA-24	NOVA-27
Shintech SE950EG (high reflectivity)	100	100
Rohm & Haas Advastab TM-181 20% monomethyl tin	2.5	2.5
DuPont R-102 rutile titanium dioxide	19	0
Kronos 1000 anatase titanium dioxide	0	19
Ferro 15F calcium stearate	0.8	0.8
Honeywell Rheochem 165-010 paraffin wax	1.1	1.1
Ferro Petrac 215 oxidized polyethylene	0.2	0.2
Rohm & Haas F1005 glycerol monostearate	0.3	0.3
Arkema Durastrength 200 Acrylic impact modifier	4.0	4.0
Rohm & Haas Paraloid K120N processing aid	1.0	1.0
wt % titanium dioxide	15	15

NOVA-24 rutile

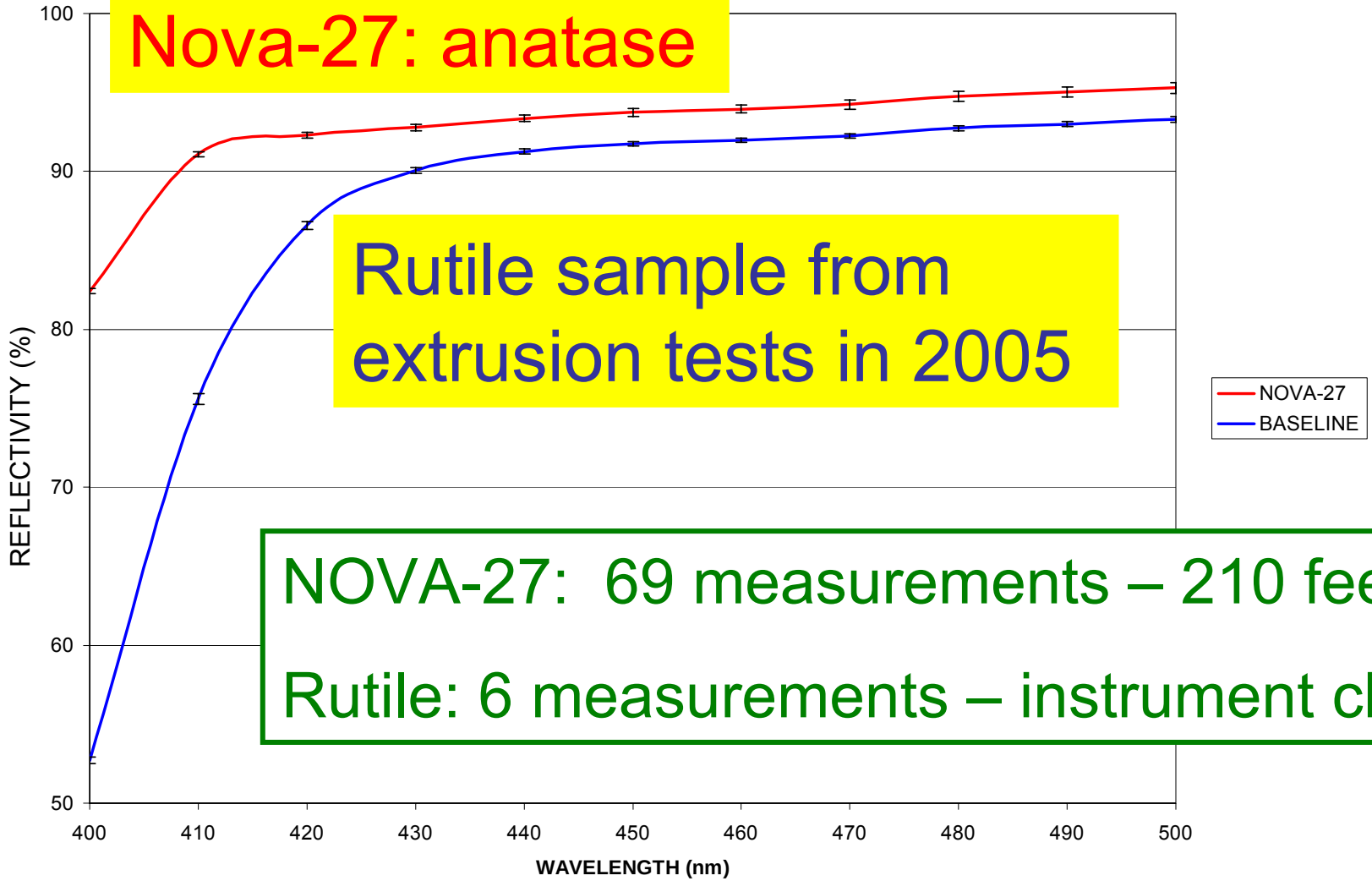
NOVA-27 anatase

All known components

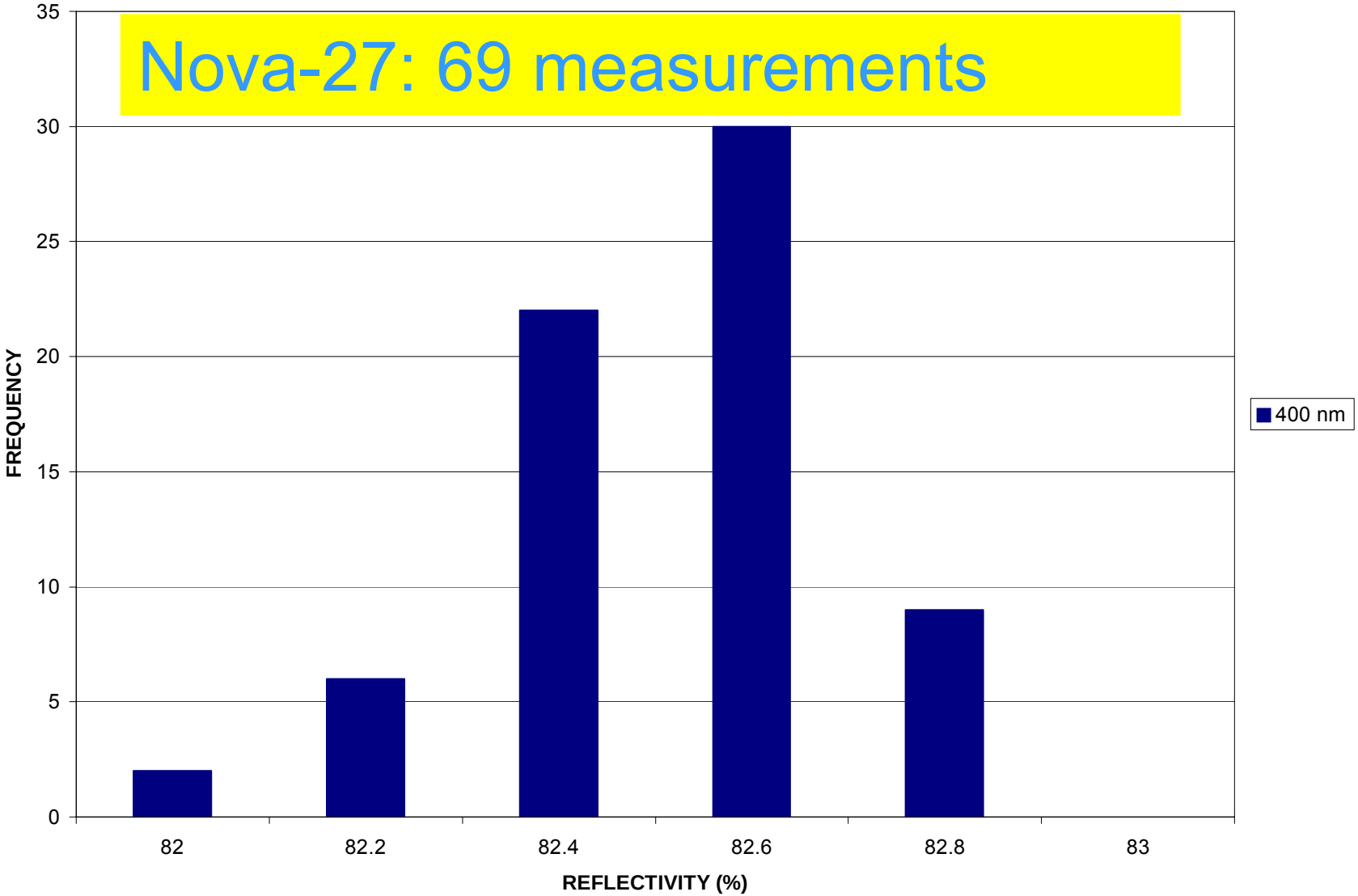
Reflectivity of NOVA-24 and NOVA-27



Reflectivity of Recent Extrusions

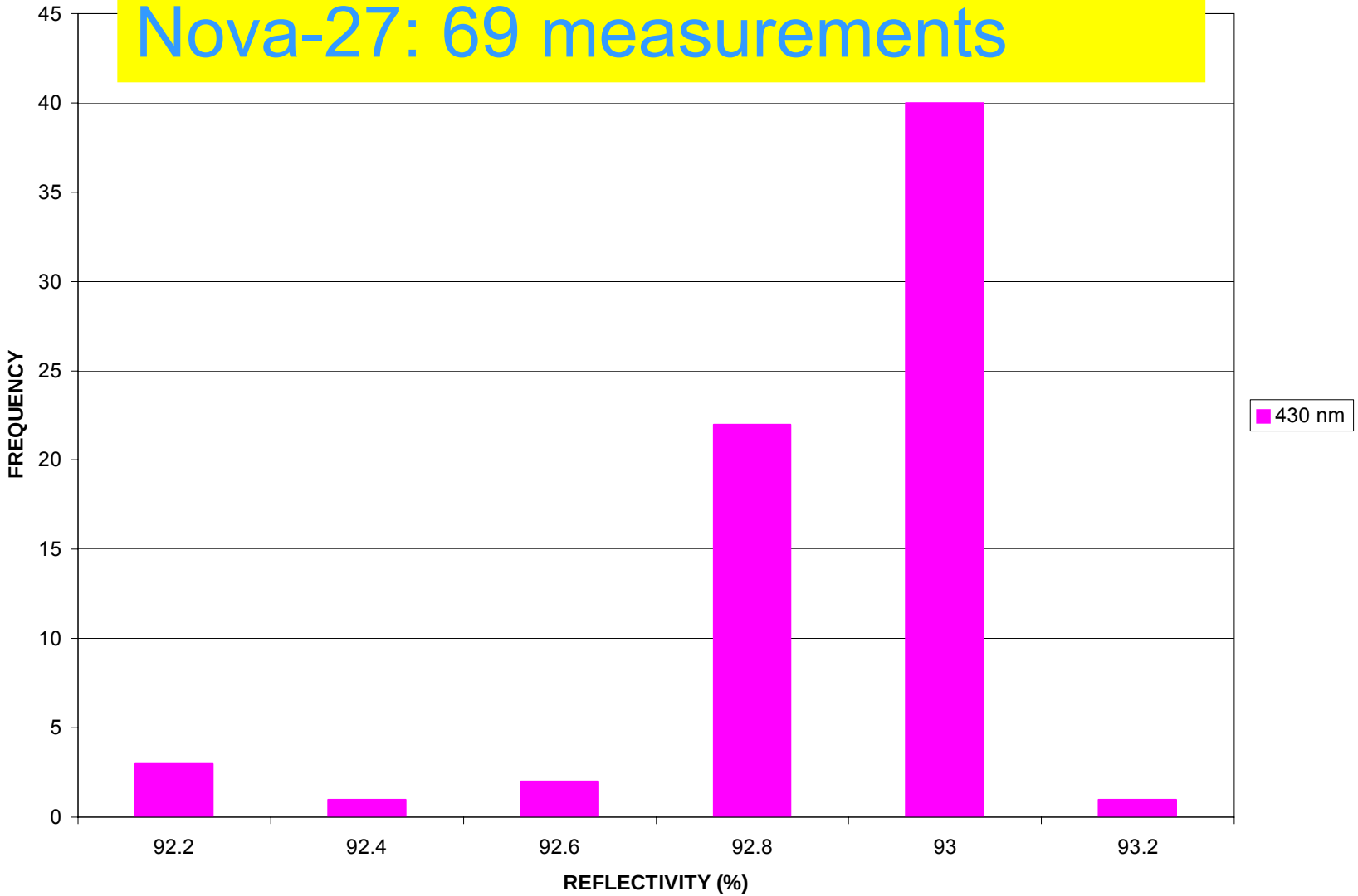


Reflectivity of Recent Extrusions

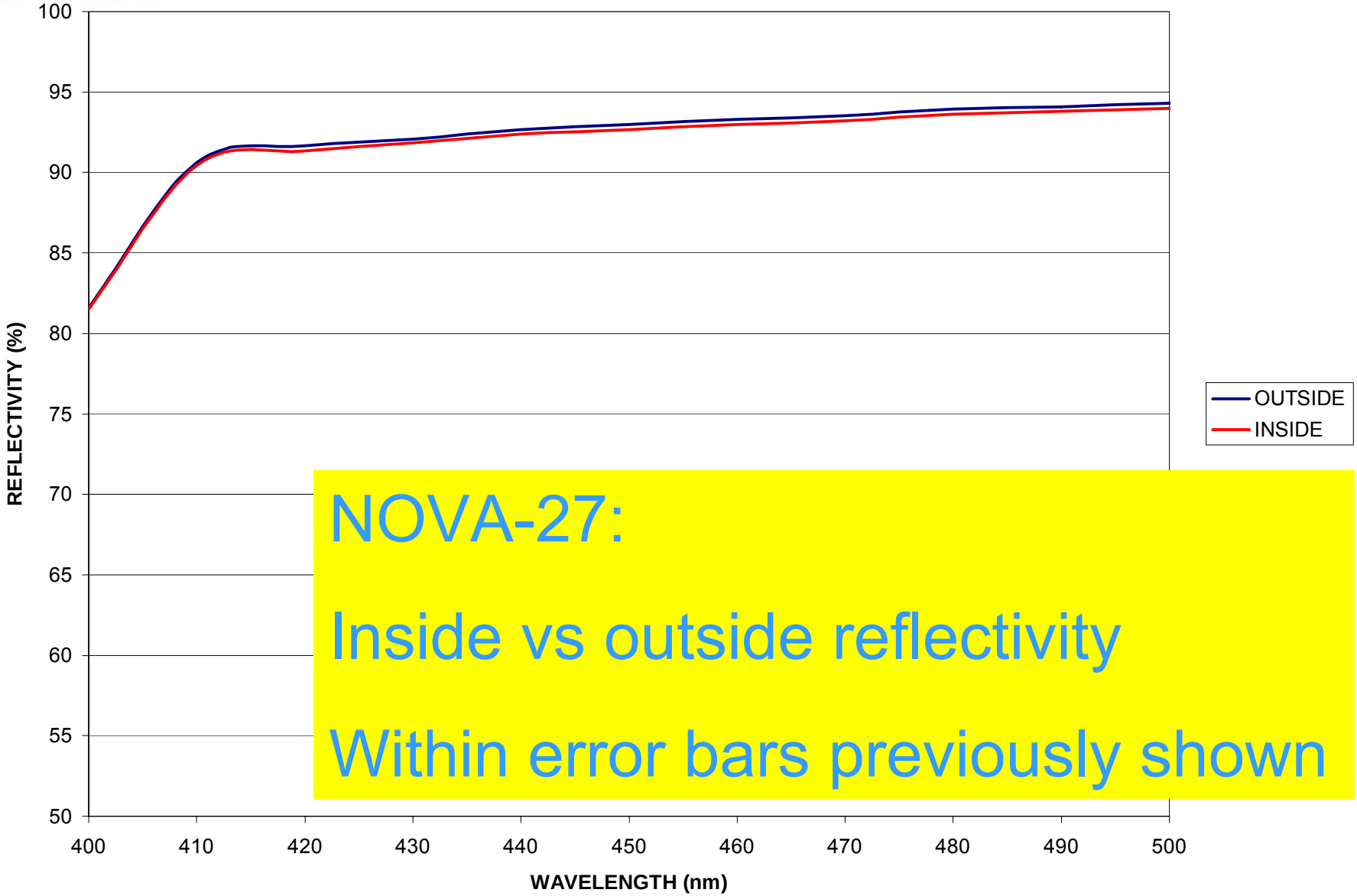


Reflectivity of Recent Extrusions

Nova-27: 69 measurements



Reflectivity of Recent Extrusions



NOVA-27:

Inside vs outside reflectivity

Within error bars previously shown

CONCLUSIONS

- NOVA-27 – ANATASE
  - It is the chosen PVC resin
  - It meets reflectivity and processability requirements
  - Its mechanical properties are being evaluated:
    - Results to date satisfy NOVA's requirements (Ref: Jim Grudzinski's breakout talk)