Overview of Filtration Media Classes, Their Properties, and Applications in Which They Excel

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Nonwovens Overview

What is a nonwoven?

Sheet or web of fibers interlocked by mechanical (friction/entanglement) or chemical (adhesion) means

Fibers may be natural or man-made but cannot include paper, fibers formed into yarns, or woven, knitted, or tufted fibers.

Fibers may be stapled, continuous, or formed in situ

Raw Material Groups used in Nonwoven Filter Media

Type	Raw Material
Natural/Bio Fibers	Cellulose, jute, wood pulp, cotton
Synthetic Polymers	Polyesters, polypropylene, polyethylene, polyamides, polyimides, acrylics
Inorganic Fibers	Glass, metals

Freedonia – Industry Study: Filters 2011-2015 – Nov. 2011
BCC Research – Nonwoven Filter Media: Technologies and Global Markets – May 2013

Classification of Nonwovens

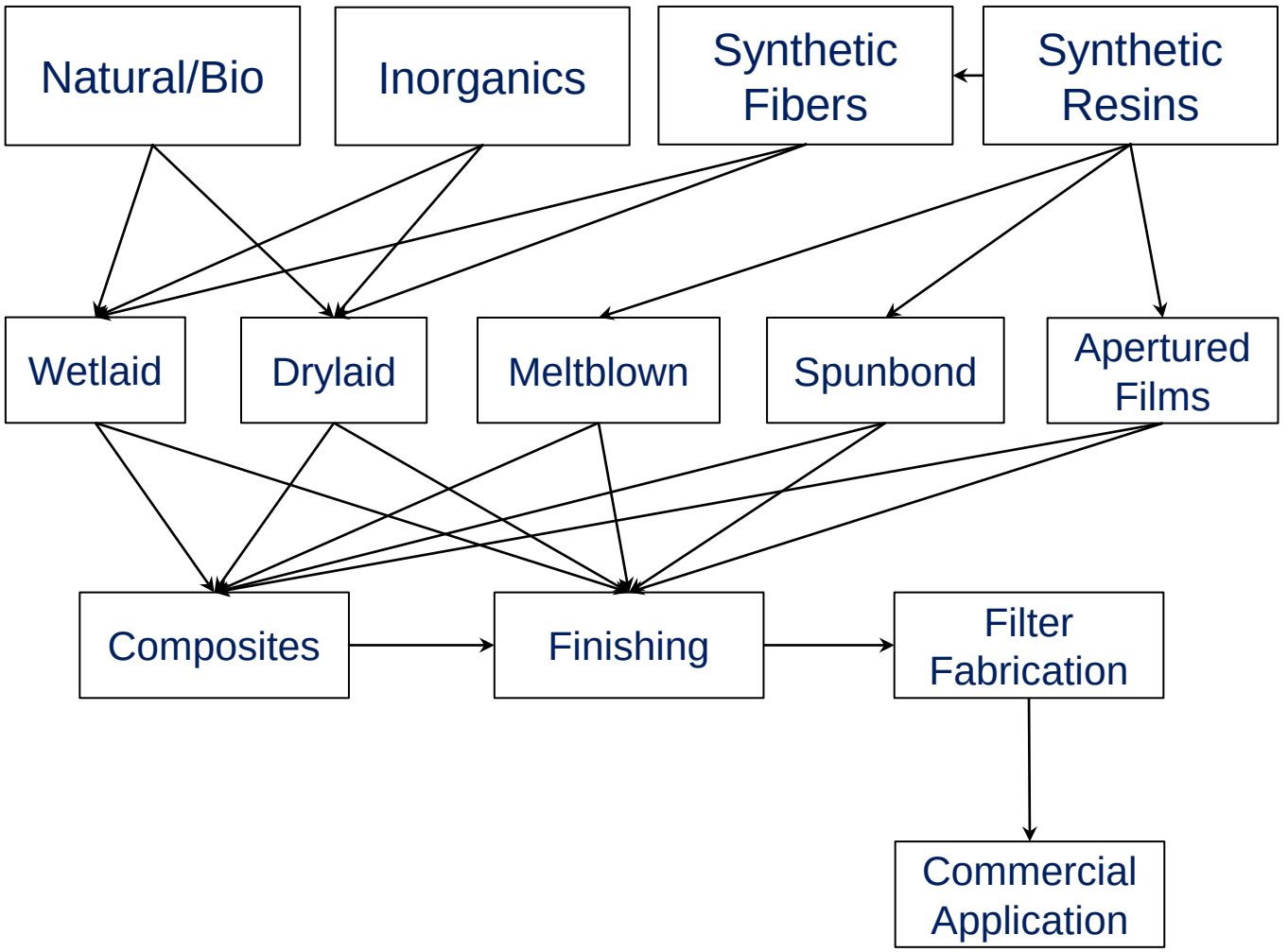
- By forming process…
  - Dry formed
    - Airlaid
    - Drylaid
    - Melt spun
      - Spunbond
      - Meltblown
      - Nanofiber web spinning
  - Wetlaid
  - Composite structures
  - Membranes

Nonwovens Overview

Fiber Materials

Forming

Product Formation



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Synthetics

Nonwovens Overview

Fiber Materials

Forming

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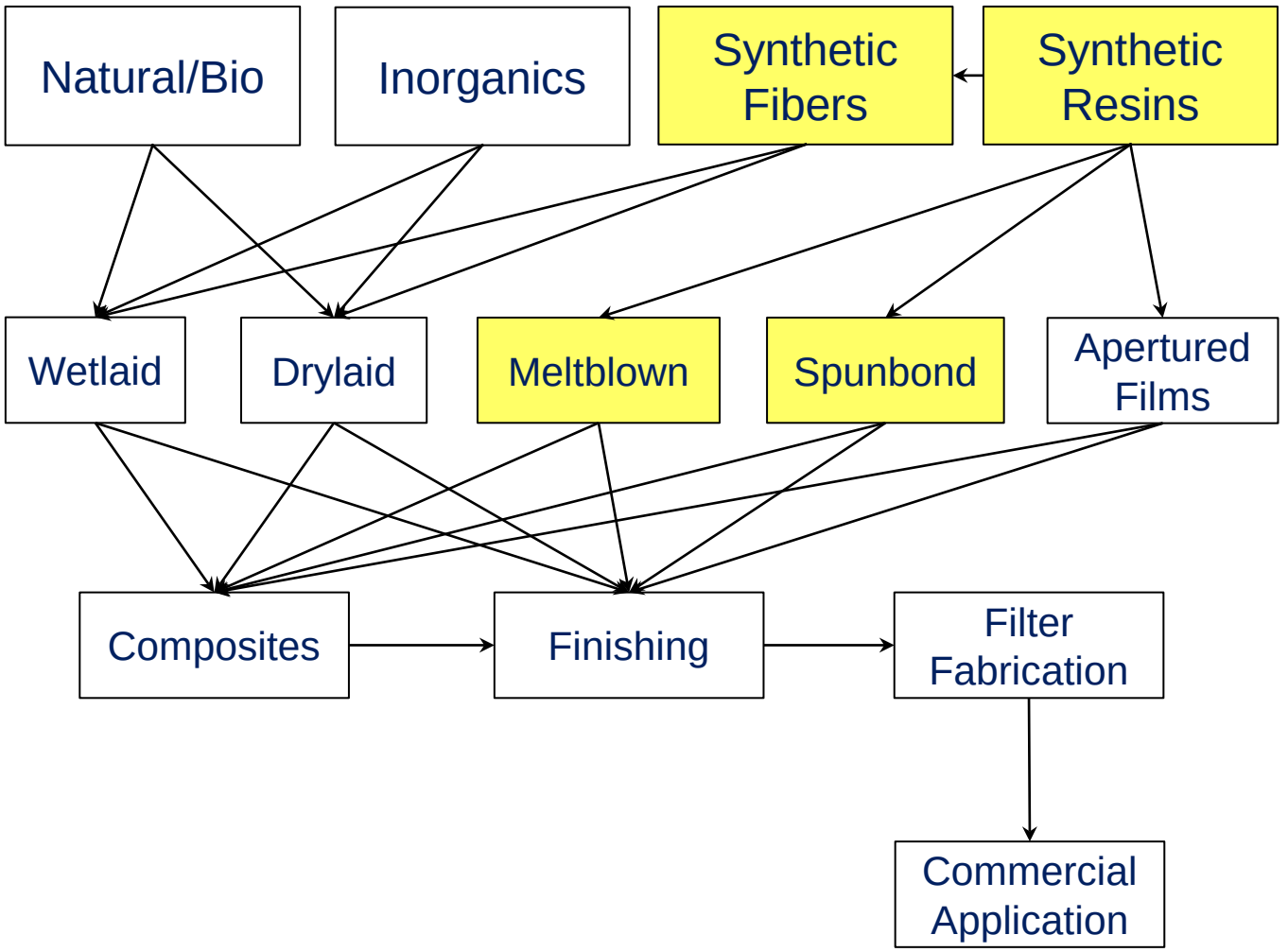

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Synthetics Overview

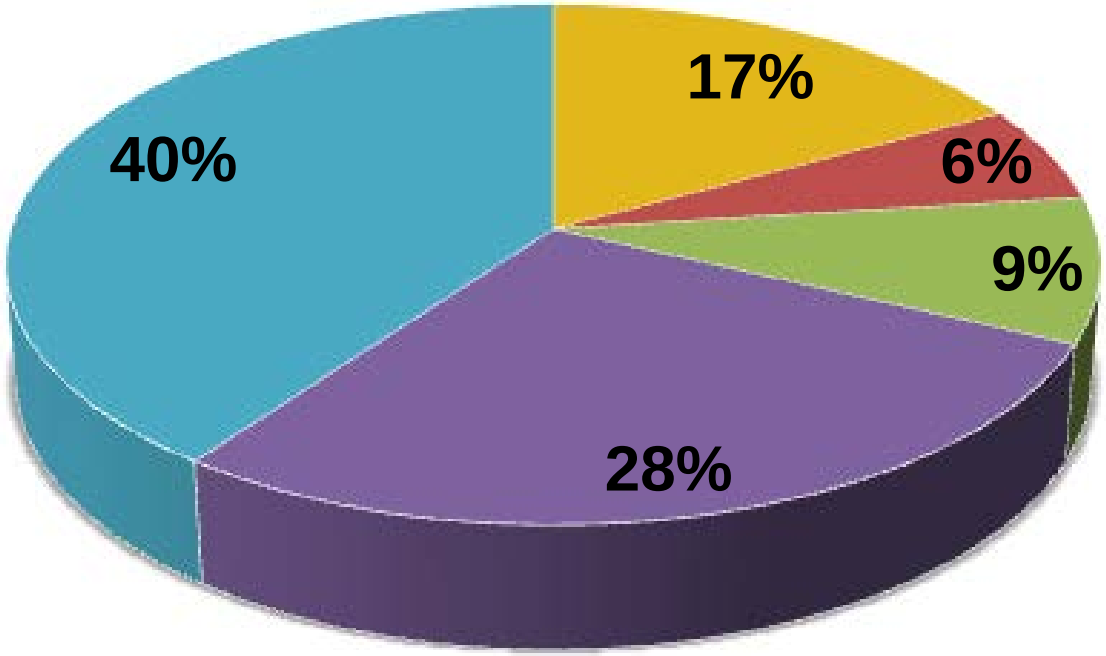
Media comprised of polymeric fibers and/or strands

Forming Techniques

- Spunbond
- Meltblown
- Apertured films

- Airlaid
- Wetlaid

Global Nonwoven Filter Market



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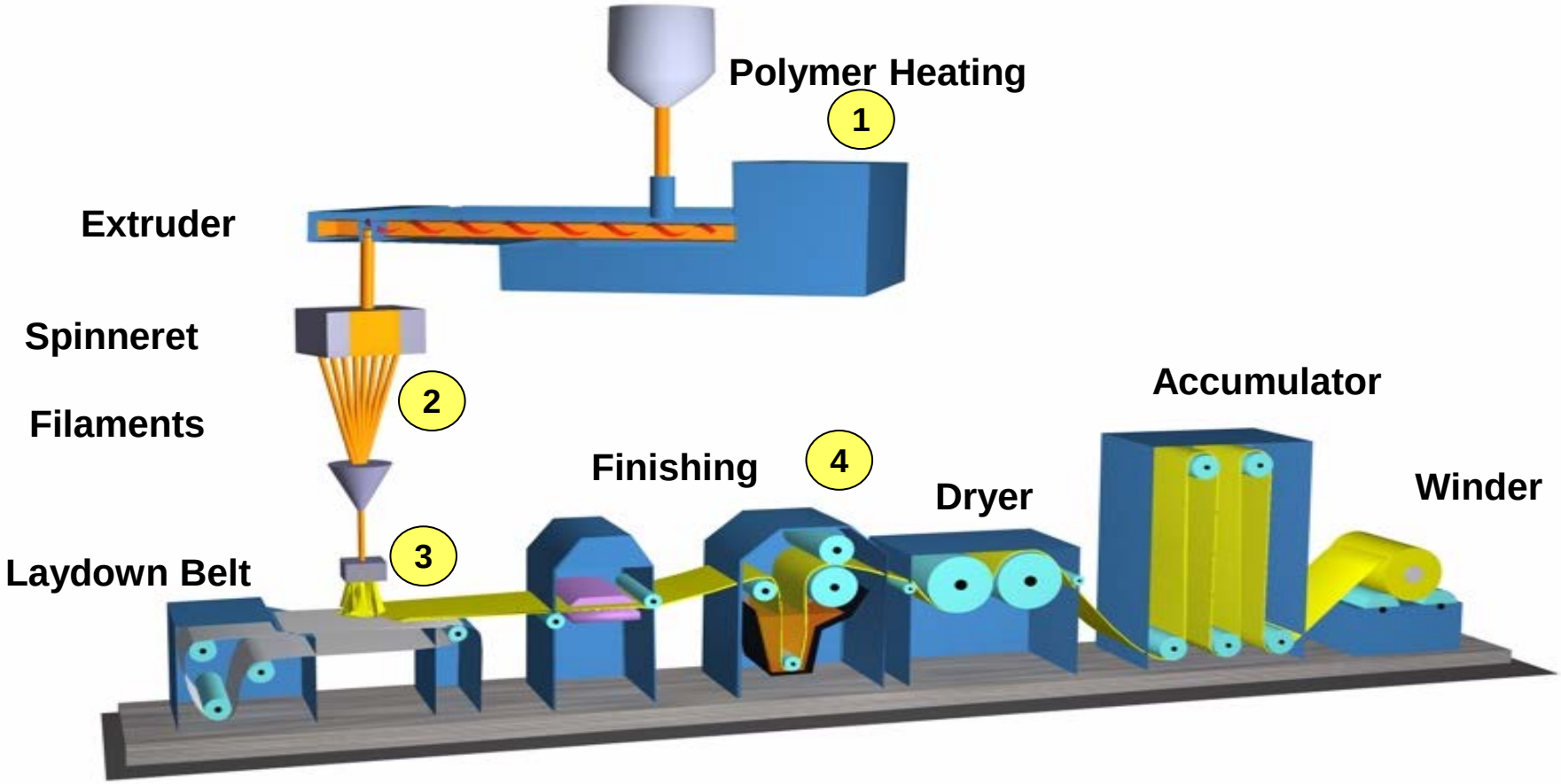
Meltblown, Spunbond – Process

1) Hot polymer resin extruded through die
2) Fibers are attenuated with forced air
3) Cooled fibers collected on laydown belt
4) Optional bonding and finishing steps



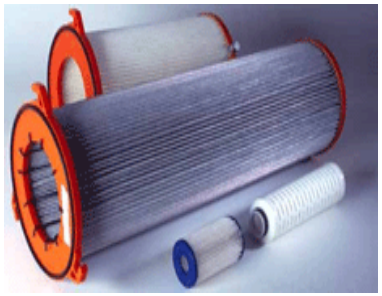
Meltblown vs. Spunbond

	Meltblown	Spunbond
Developed	1950s	
Opacity	Opaque	
Color	Typically white, can be colored	
Finishing	Calendar, laminating, point bonding	
Pleatable (Y/N)	Yes, when heavy enough	
Basis weight avg.	20 - 200 gsm	10 - 200 gsm
Basis weight range	8 - 350 gsm	5 - 800 gsm
Fiber diameter avg.	2 - 6 µm	15 - 35 µm
Fiber diameter range	0.5 - 15 µm	1 - 50 µm
Fiber length	Discontinuous	Continuous
Fiber orientation	Random	Random - somewhat aligned
Fiber attenuation	Strong air, at die exit	Less air, away from die
Typical polymers	PP, PE, PBT, etc.	PP, PET, PBT
Economics	Less capital	Faster, cheaper production
Binders	Self-bonding, binders optional	Chemical binders, needling
Media properties	Soft	High stength : weight

Applications Suited for Synthetics

Filtration

- Depth filtration and surface exclusion
- Suitable for air or liquid filtration
- Better suited to liquid filtration than glass
- Support layers for other filters



Textiles/Medical Uses

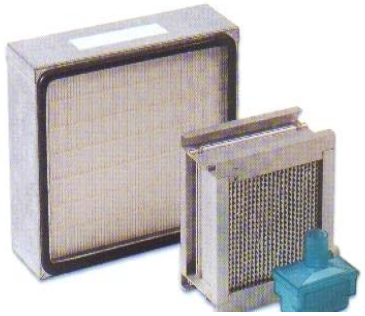
- Hygiene/sanitary products
- Diapers, masks

Other Uses

- Geotextiles (erosion control, reinforcement)
- Absorbents
- Packaging

When to Choose Synthetics?

- Economics
  - + Bulk polymers are relatively inexpensive
  - + Less energy to melt and process than glass
  - - Fine diameter fibers are costly



- Application performance (properties)
  - + Variety of polymers and properties
  - + Multi-component fibers
  - - High temperature limitations
  - - Polymer degradation (oxidation, UV, chemical)

- Manufacturing/handling
  - + Easier startup and changeover
  - + Varied filter dimensions and orientations
  - - Fine fibers: low throughput and poor distribution
  - - Media can carry residual charge – particularly meltblown

Synthetics - Market

- Total nonwoven filtration market: $3.5B in 2012
- Growth rates[1] **[5 yr CAGR (%) 2013-2018]**
  - Nonwoven filter media demand: 9.8%
  - Filter demand: 7.1%
- Nonwoven filters growing at 7-10% depending on platform through 2018[2]

Nonwoven Filter Market Shares

Market Application	Market Share (%)
Transportation	22
Water filtration	20
HVAC	14
Food & beverage	12
Healthcare	11
Manufacturing	10
Advanced technology	6
Hydrocarbon processing	5

Nonwoven Filter Global Market

	2005	2010	2012	2013	2018	5 yr CAGR (%) 2013-2018
Sales, $ Million	2118	2739	3499	3745	5319	7.3

[1]Freedonia – Industry Study: Filters 2011-2015 – Nov. 2011
[2]BCC Research – Nonwoven Filter Media: Technologies and Global Markets – May 2013

Synthetics - Improvements

- Composite media – benefits of multiple media types
- New and expanded polymer chemistries
  - Unique filtration and chemical properties
  - Sustainable fiber sourcing
  - Biodegradable and disposable media
- New and expanded additives
- Narrow fiber diameter distribution
- New post-process treatment and finishing
- Improved nanofiber production – faster, cheaper, more consistent on larger scale
- Improvements in pressure drop, capacity, durability, longevity

Synthetics - Areas of Growth

- Expand/new products in food/beverage and bio/pharma
- Replace cellulose in numerous filters
- Bridge to membranes (efficiency of membranes for less cost)
- New technology - nanofibers
- Clean air/water (regulatory requirements, public awareness)

Filtration Classes and Suitable Media

Filtration Technology	Particle Size Removed	Best-suited Media
Coarse Screening	> 2000	Mechanical Sieves
Coarse Filtration	70 - 2000	Nonwovens
Fine Filtration	.1 - 70	Nonwovens
Microfiltration	0.1 - 1	Nonwovens, Membranes
Ultrafiltration	0.005 - 0.1	Membranes
Nanofiltration	0.001 - 0.005	Membranes
Reverse Osmosis	~0.001	Membranes

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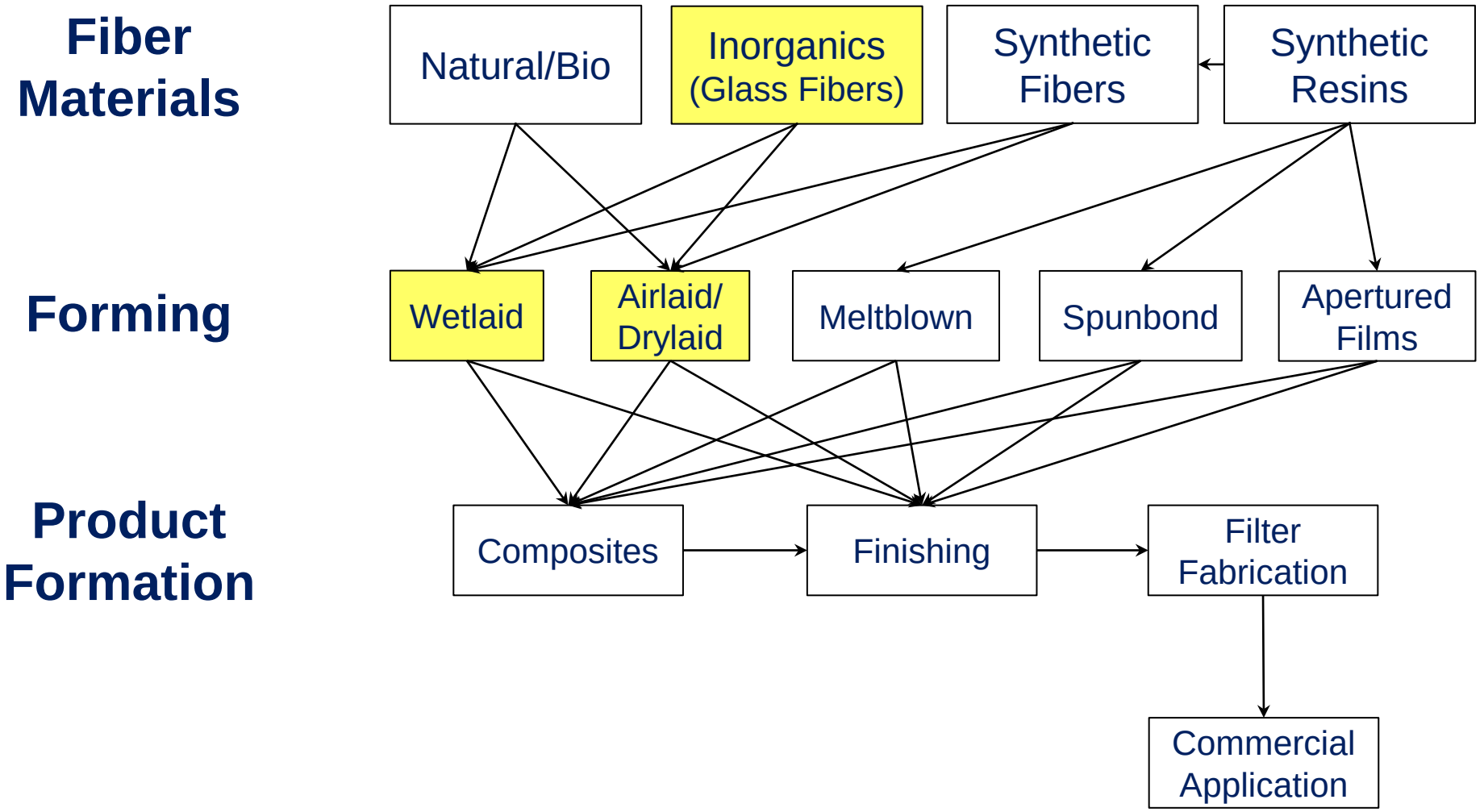
Glass

Nonwovens Overview



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Classification of Nonwovens

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  - Dry formed
    - Airlaid → **Glass fiber nonwoven (rolled goods)**
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      - Spunbond
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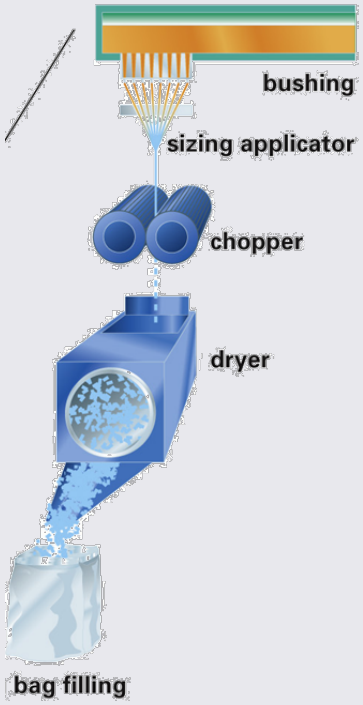
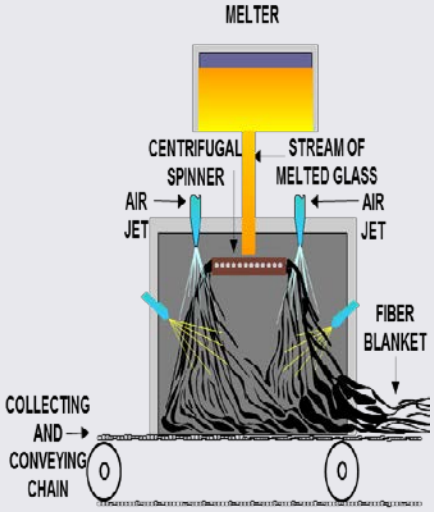
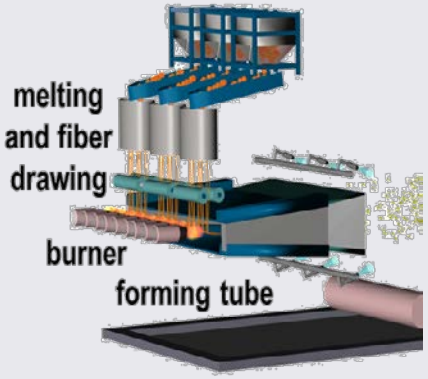
      - Nanofiber web spinning
  - Wetlaid → **Glass fibers (bulk fibers)**
  - Composite structures
  - Membranes

Glass Fibers in Nonwovens

- Method of manufacture
  - Continuous draw fiberization
    - Melt pulled through a myriad of holes in a noble metal (non-reactive) bushing and stretched to the desired diameter, cut/chopped to length
  - Centrifugal (rotary) spinning
    - Two-step attenuation
      - Initial formation of a primary melt stream from holes in the sidewalls of a spinning disc
      - Fragmentation of melt stream in an air or hot gas jet
  - Flame attenuation
    - Two-step attenuation
      - Secondary fragmentation of a primary melt stream through use of high velocity/high temp gas jets

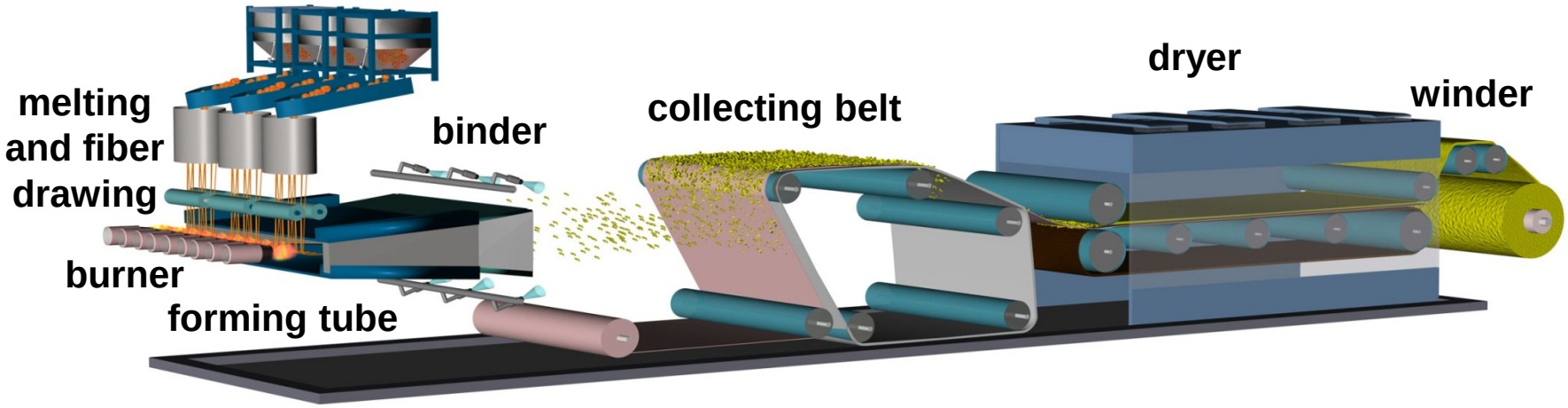
* Bauer, J. F., “Properties of Glass Fiber for Filtration: Influence of Forming Process”, *J. Eng. Fibers and Fabrics*, Winter 2004

Glass Fibers in Nonwovens

	Continuous Draw	Rotary Spinning	Flame Attenuation
Mean Fiber Diameter	3 µm to 25 µm (8 to 16 µm most common)	2 µm to 8 µm	0.1 µm to 5 µm
Fiber Diameter Distribution	Narrower, normal distribution	Broader, positive skew	Broader, positive skew
Fiber length	Continuous, cut to length	Discontinuous	Discontinuous
Process Diagram			

Air Laid Glass Nonwoven (Rolled Goods)

- Flame attenuated, bonded/unbonded blanket (rolled goods)
- Filtration applications
  - Air filtration (HVAC – ASHRAE grades)
  - Liquid filtration (coalescence/mist elimination)



Bulk Glass Fibers for Wetlaid Nonwovens

- Continuous draw, rotary spinning, and flame attenuation techniques employed for manufacture of bulk glass fibers
- Manufactured into a nonwoven through a wet laid process
- Filtration applications
  - Air filtration (HVAC: ASHRAE, HEPA/ULPA)
  - Liquid filtration (automotive; hydraulic; laboratory)

When to Choose Glass?

- Economics
  - + Very small fiber diameters achievable at lower cost and higher throughput, relative to polymers
  - - Energy intensive production (melt glass)
- Application performance (properties)
  - + High temp/chemical resistance
  - - Fibers are not self-contained – restraint (binder/backing) may be needed to prevent fiber shedding
- Manufacturing/handling
  - + Raw material and finished product storage not as sensitive (UV, oxidation, etc)
  - - Labelling/REACH registration of respirable fibers

Opportunities/Future for Glass Fibers

- Glass chemistry development (biosolubility)
- Fiber surface properties
- More controlled/tighter fiber dimension distribution
- Optimized aspect ratios (diameter/length) for strength and filtration performance

Review/Conclusion

- Both glass and synthetic polymers are proven materials for a range of filtration applications
- Many factors to consider when selecting a filter material
  - Basis weight, permeability
  - Structural/surface (thickness, density, porosity)
  - Strength (tensile, tear, burst, stiffness)
  - Moisture-related properties (repellency, resistance)
  - Filtration performance
  - Processability