Antibacterial Melt Blown PP - g – NDAM Nonwoven

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Sustainable Textiles and Medical Protection

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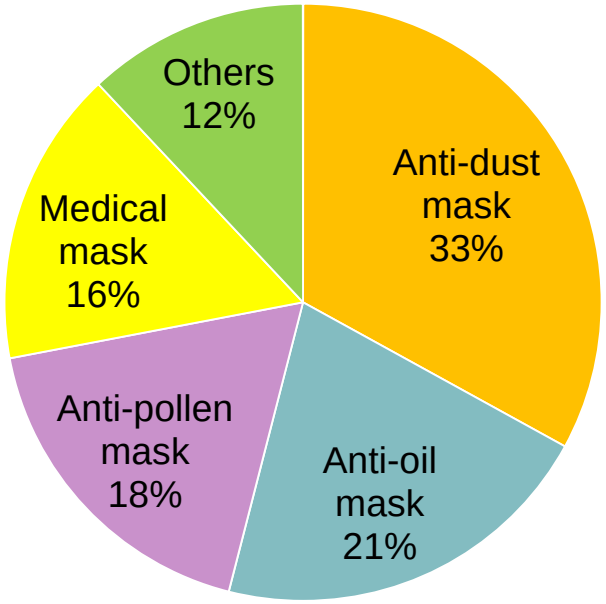
Introduction

- ***Face Mask classified by use:***
  - Anti-dust face mask
  - Medical face mask
  - Anti-oil face mask

- ***Face Mask Annual Output in China: 30 billions***

Distribution of main face mask products



Introduction

- ***Medical Face Mask Classified by Structure***
  - Plane Mask
  - Molded Mask

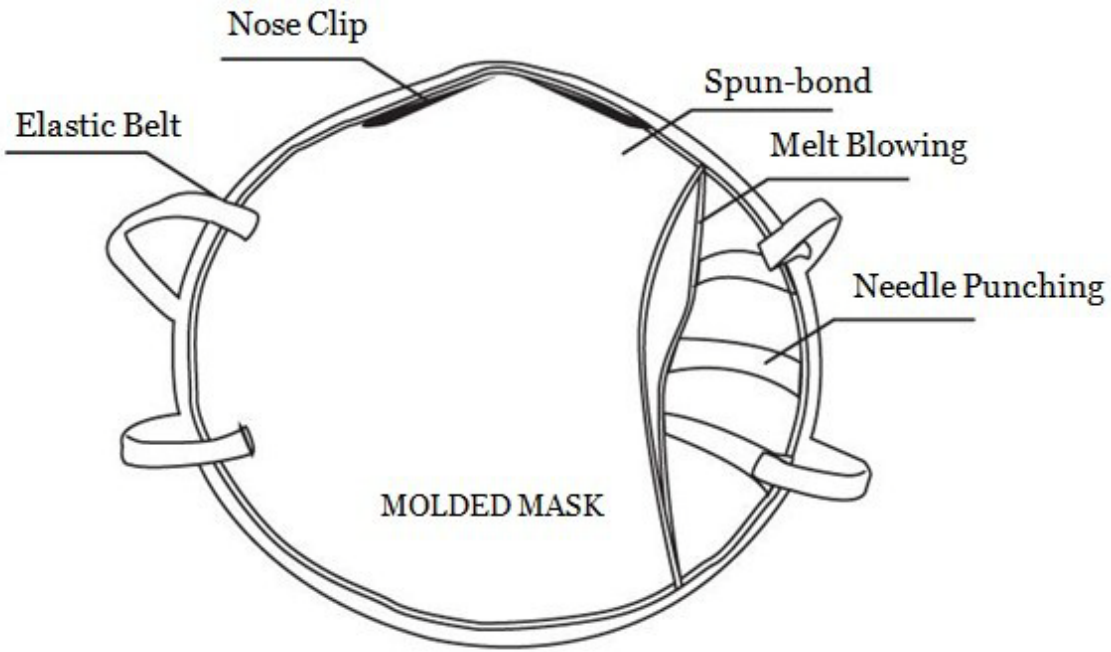
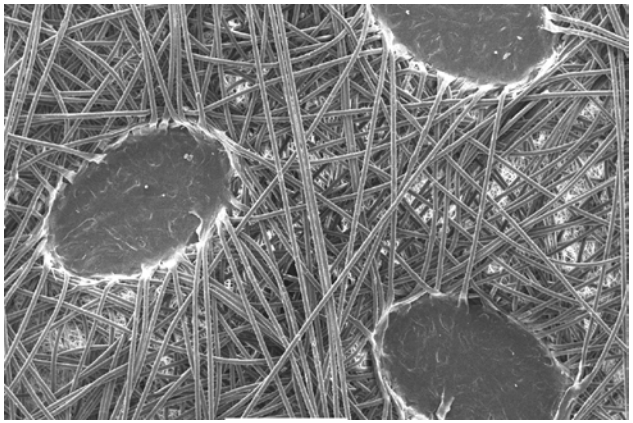


Fig.1 Molded Mask Structure

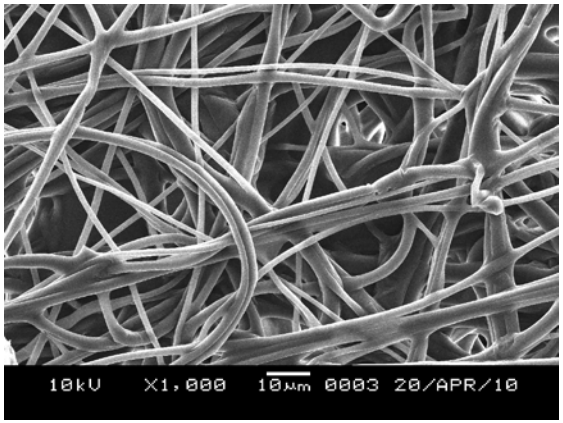
Introduction

◆*Materials of Molded Medical Face Mask*

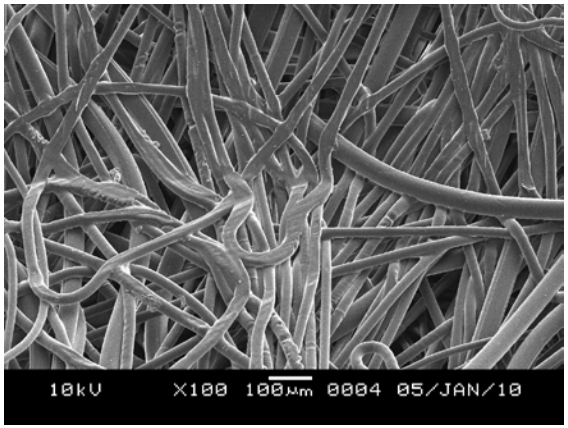
4 layers	Fibers fineness	Composition
➢ Outer layer: Spun-bond	16~20 μm	PP
➢ Interface layer: Melt Blowing	1.5~2 μm	PP
➢ Skeleton layer: Needle Punching	14~25 μm	PET
➢ Inner layer: Spun-bond	16~20 μm	PP



Spun-bond



Melt blowing



Needle Punching

Introduction

- ***Antibacterial Medical Face Mask***

Nano Sliver Antibacterial Medical Face Mask

- Mechanism : Nano-silver damages the cell wall and genetic composition of bacteria
- Non-reusable
- Low Sterilizing Rate
- Short time use

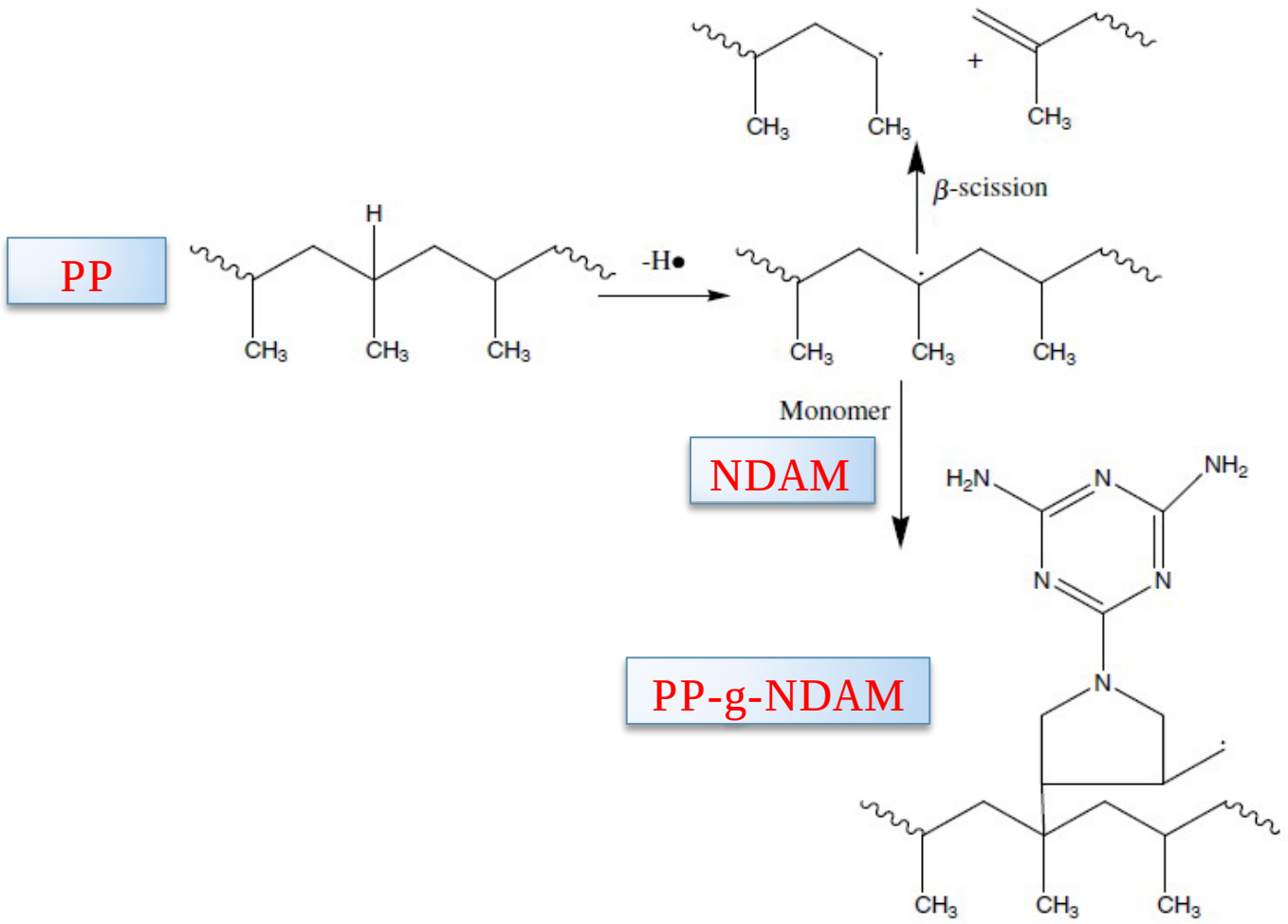
Antibacterial PP-g-NDAM Medical Face Mask

- Active chlorine kill bacteria
- Active chlorine can be rechargable
- More stable antibacterial property
- High Sterilizing Rate
- Long time use

Introduction

◆*Grafting Reaction of PP with NDAM*

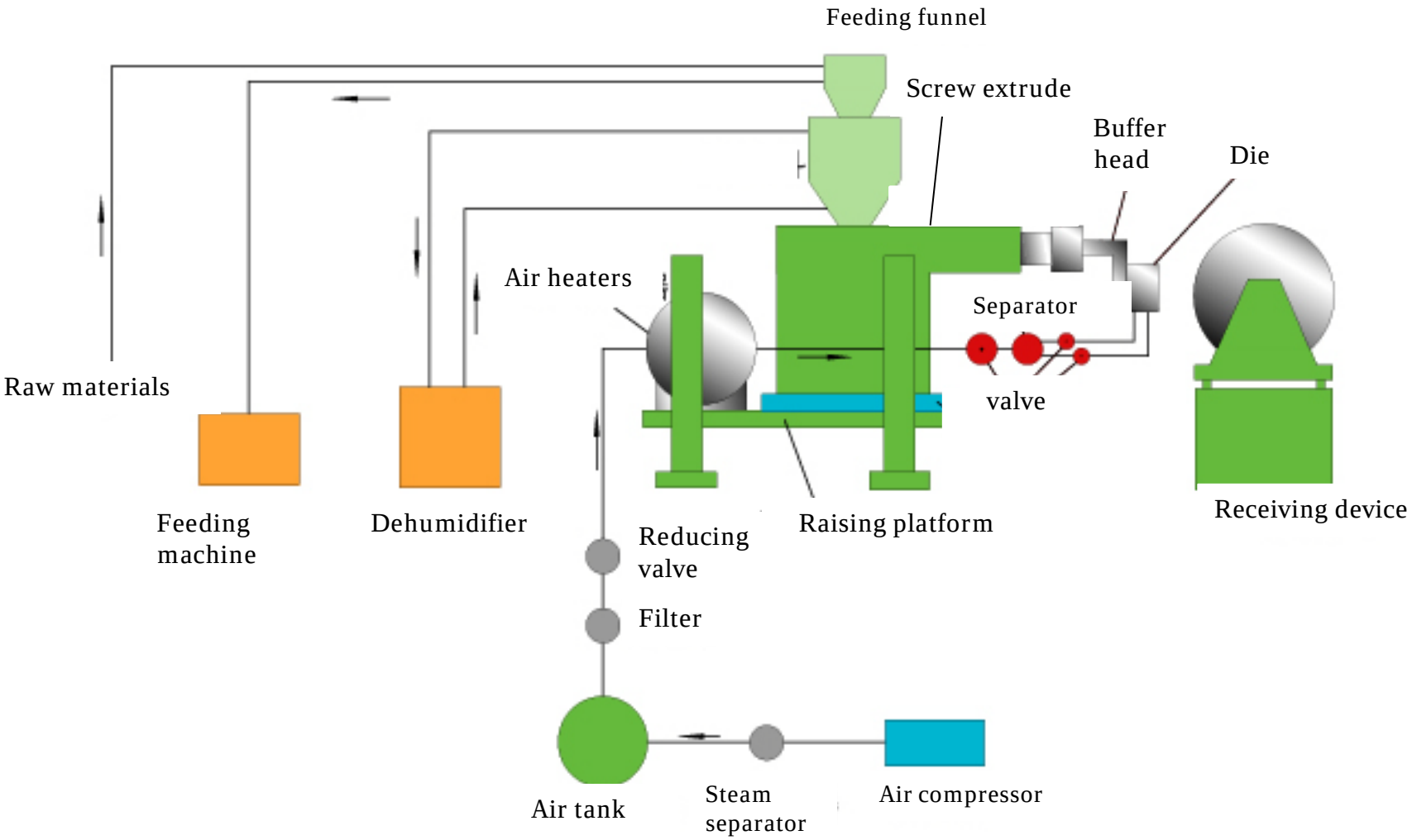
N- halamine precursor, 2, 4-diamino-6-diallylamino-1, 3, 5-triazine (NDAM)



Scheme 2. Reaction of PP with NDAM in reactive extrusion.

Melt Blown Process

◆*Polymer Melt Blown Device*



Melt Blown Forming

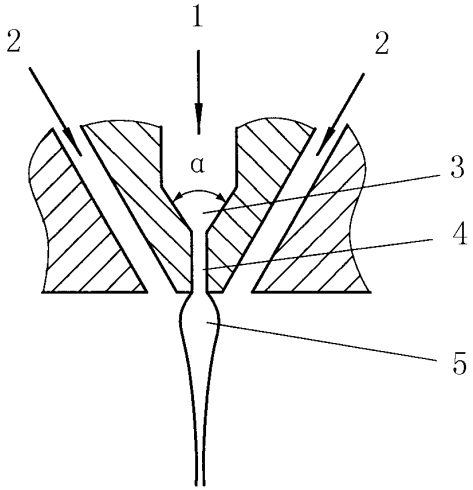
Outline

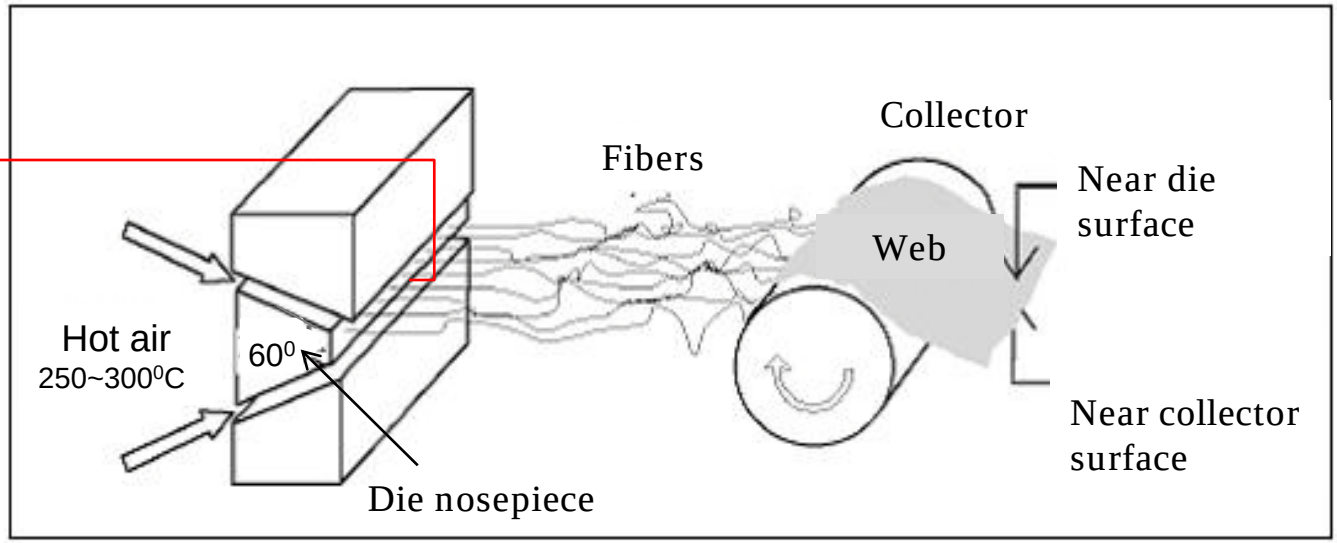
1st experiment*	• Melt blown Process • Performance testing of raw materials • Basic Property test • SEM
2nd & 3rd experiment*	• Melt blown process • Basic Property test • Fineness & Pore diameter test (for 3rd sample) • Filtration test(for 3rd sample) • SEM
Antibacterial test	• Content of active chlorine test (for the 3rd sample) • Antibacterial property test (for the 3rd sample)

* The PP-g-NDAM which used in experiment 1st ,2nd & 3rd were synthesized at different time.

Melt Blown Process

PP - g – NDMA Melt Blowing Process





1-Polymer melt
2-Hot air
3-Inlet region
4-Orifice flow region
5-Swelling region

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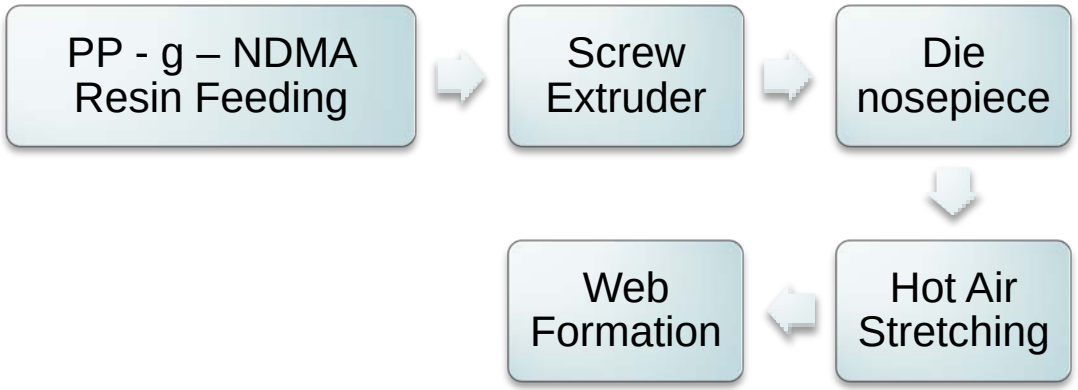


Melt Blown Process

- ***Characters of Melt Blown Materials***
  - Superfine fibers: 1.5~2.5μm (Fig. 1)
  - Randomized crossover arrangement of fibers
  - Many curved channels (Fig. 2)
  - Small pore diameter (Fig. 3)
  - Fluffy structure

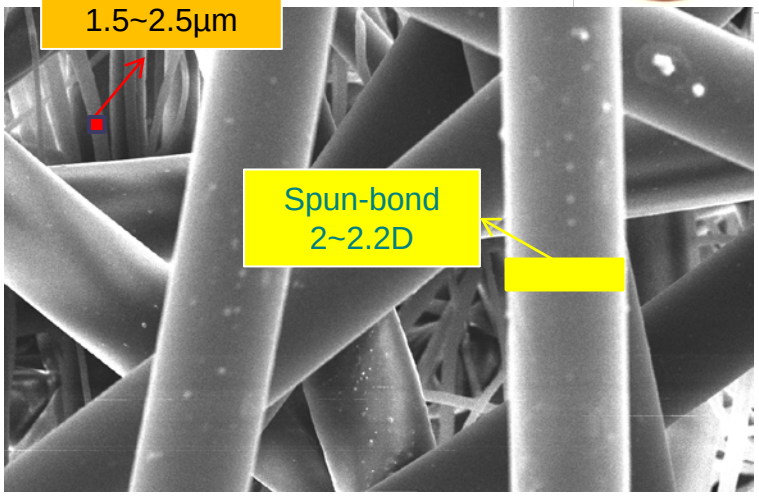


Fig.1 Fiber fineness of melt blown & spun-bond

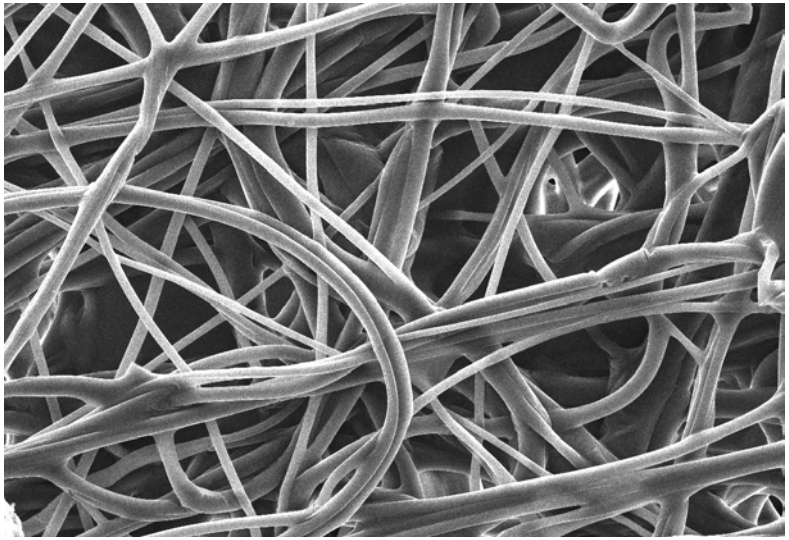


Fig. 2 Curved channels of melt blown

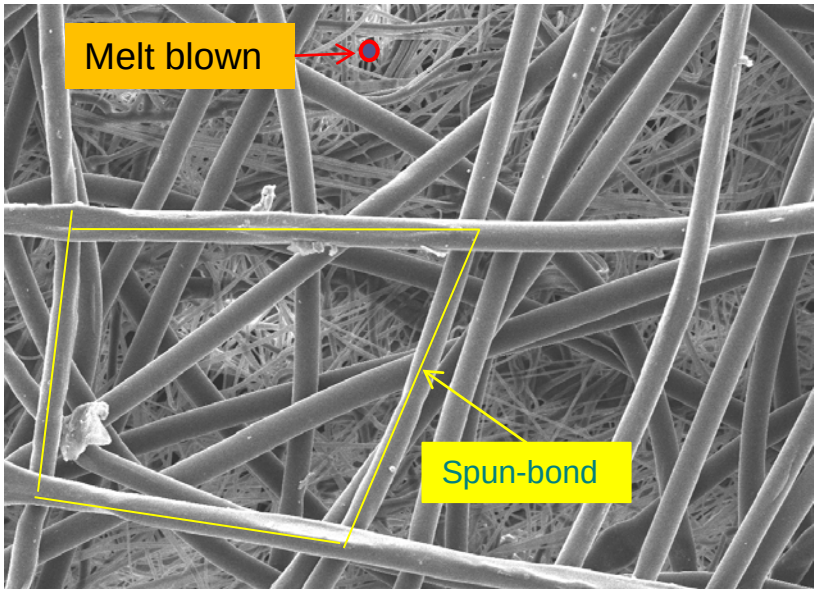


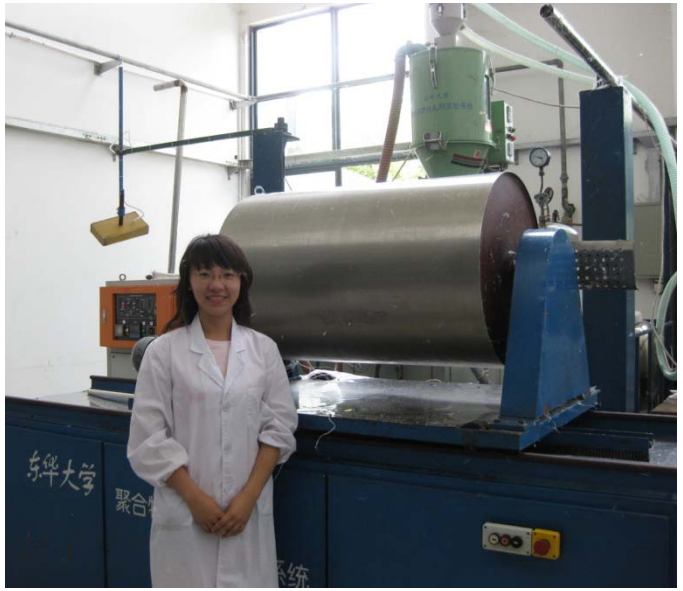
Fig. 3 Pore diameter of melt blown & spun-bond

Melt Blown Process

The 1st Experiment

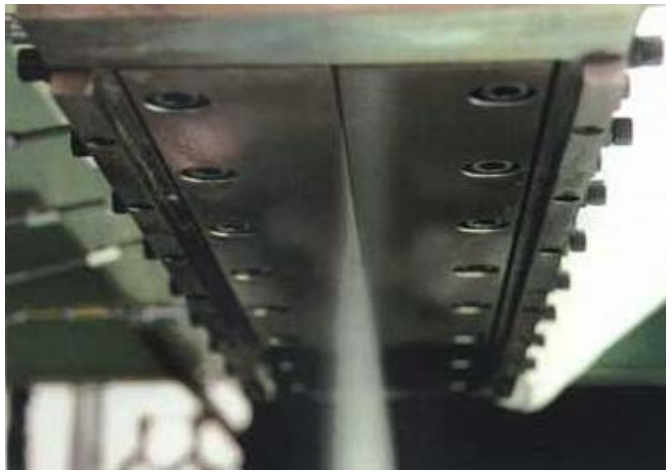
◆ *Parameters of Melt blown process*

- Spinning temperature : 300 ~ 350° C
- PP MFI 25
- Diameter of Orifice： 0.25mm
- length to diameter ratio of Screw Extruder: 35:1



◆ *Problems during Melt blown Process*

- Easy to high-temperature degradation of NDAM
- Pungent odor of the fabrics
- Fabric are yellow
- Orifices blockage
- Filament breakage
- Shots in the fabric

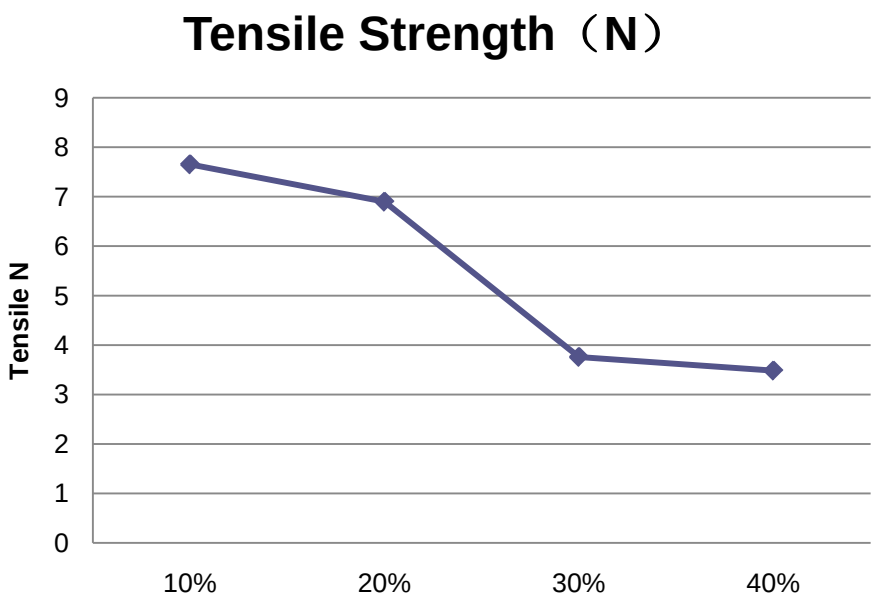


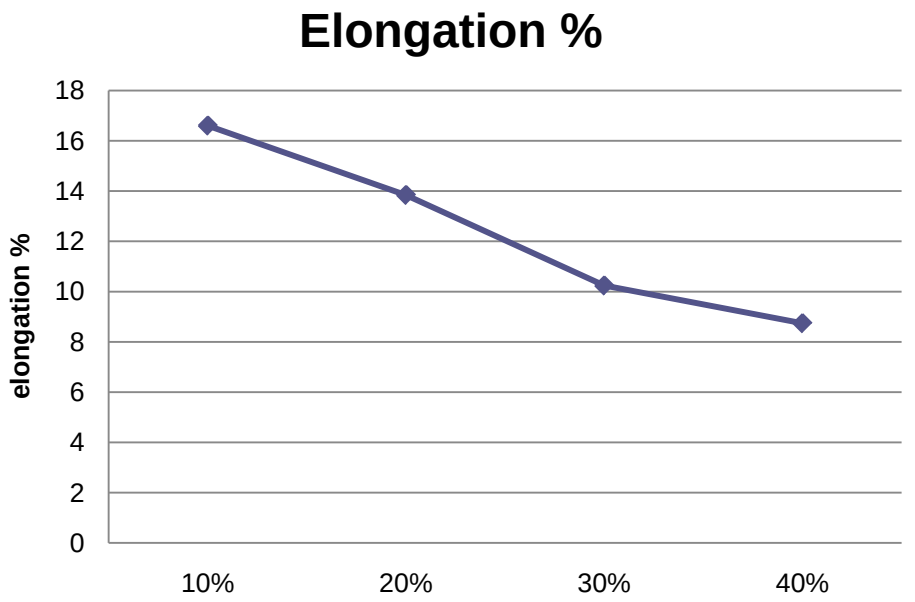
Melt Blown Process

The 1st Experiment

Basic Performance

Content of modified pp(%)	10	20	30	40
Thickness(mm)	1.08	0.67	0.56	0.53
Weight (g/m^2)	77.69	75.56	72.14	71.87
Tensile (N)	7.65	6.89	3.76	3.48
Elongation(%)	16.6	18.84	10.24	8.74

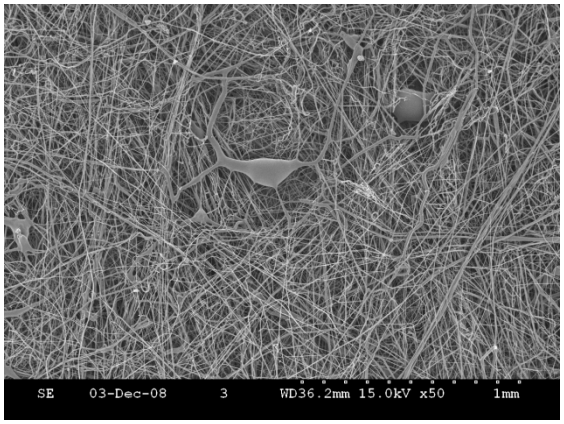




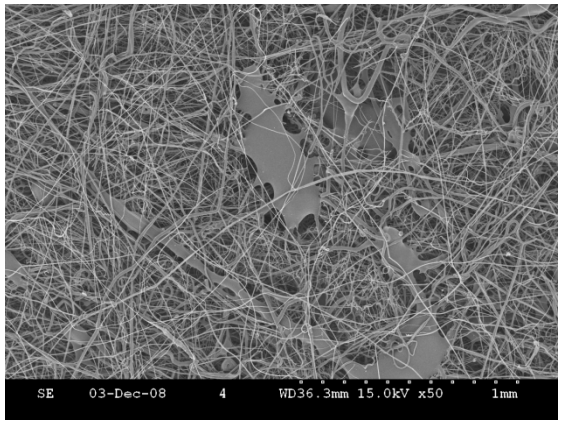
Melt Blown Process

The 1st Experiment

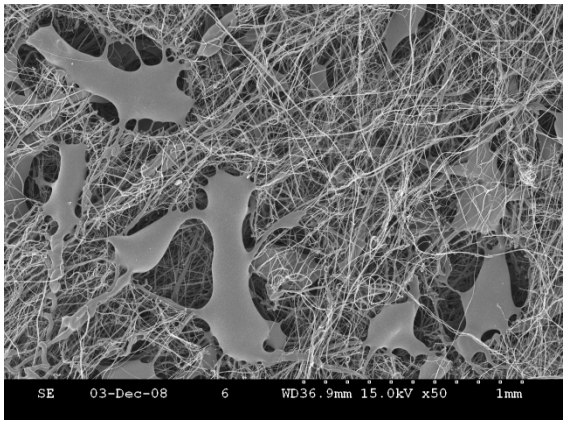
- **Fabric Structure**



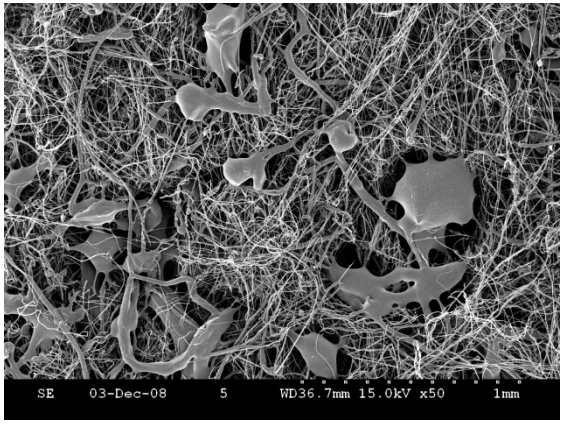
10% modi PP



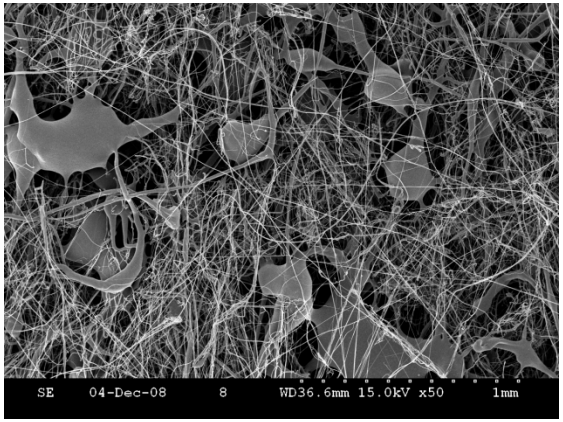
20% modi PP



30% modi PP



40% modi PP



50% modi PP

Melt Blown Process

The 2nd & 3rd Experiment

◆***Parameters of Melt blown process***

- Spinning temperature : 240 ~ 280° C
- PP MFI 1500
- Diameter of Orifice： 0.25mm
- length to diameter ratio of Screw Extruder: 35:1

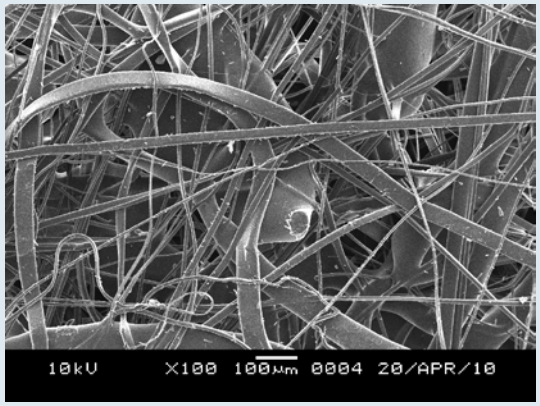
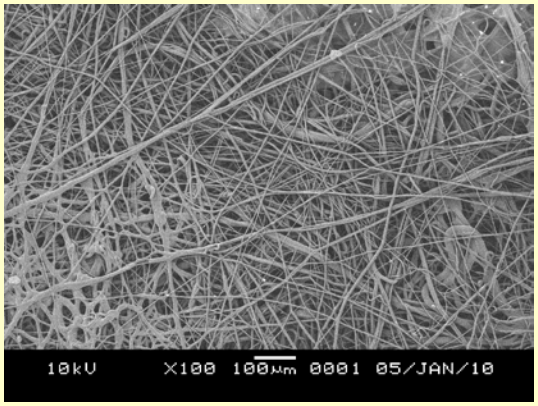
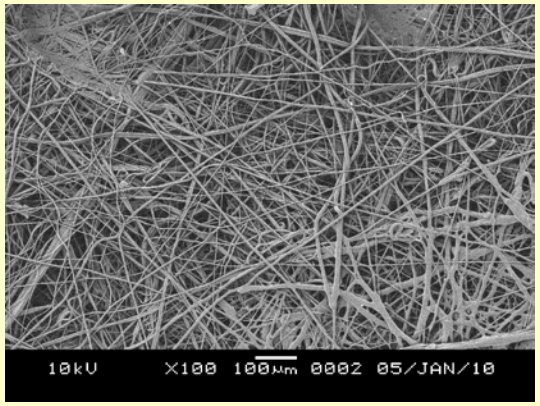
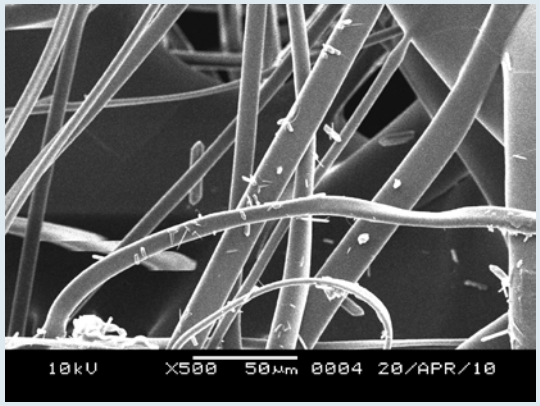
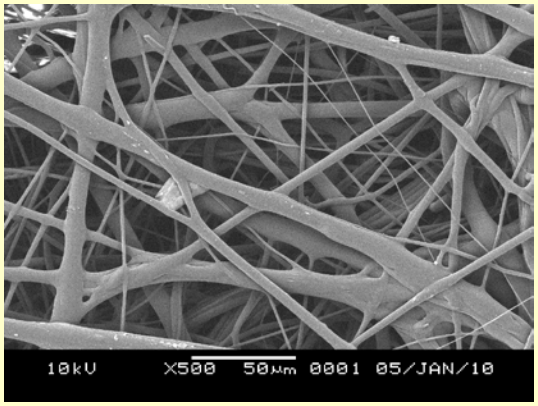
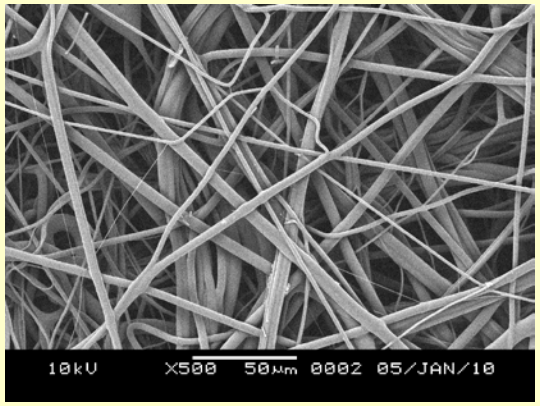
◆***Melt blown Process***

- The 2nd experiment is better than the 1st
- The 3rd experiment is the best
  - Easy to forming
  - White fabric
  - Feel fluffy and smooth of the fabric
  - Non-pungent odor of the fabrics

Melt Blown Process

The 2nd & 3rd Experiment

- **Fabric Structure**

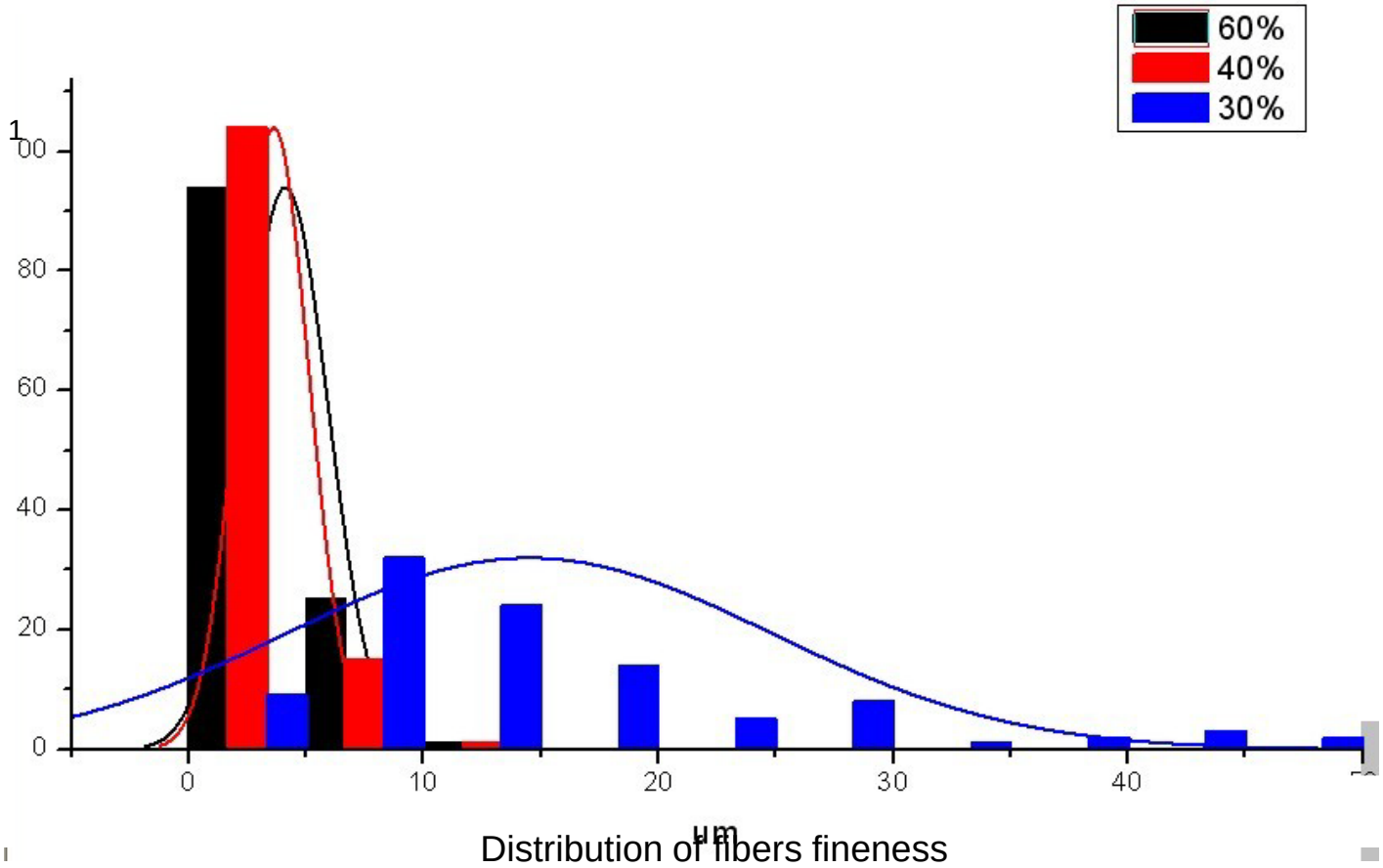
	The 2nd experiment	The 3rd experiment	
x100			
	30% PP- g - DAM	40% PP- g - DAM	60% PP- g - DAM
x500			

Melt Blown Process

- ***Fibers Fineness***

The 2nd & 3rd Experiment

Content of PP-g-NDAM (%)	30	40	60
Fibers Fineness (μm)	14.75±10.06	3.61±1.46	4.1±1.82



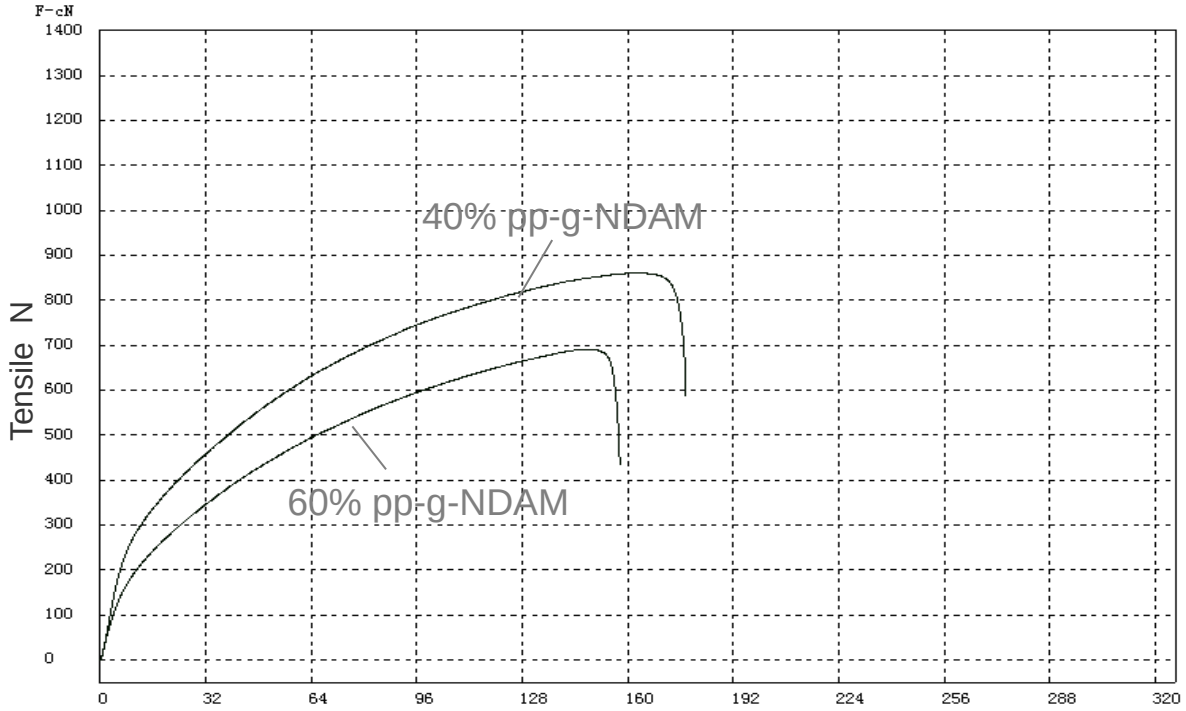
Distribution of fibers fineness

Melt Blown Process

Basic Performance

The 2nd & 3rd Experiment

Content of PP-g-NDAM (%)	Thickness (mm)	Weight (g/m^2)	Tensile (N)	Elongation (%)
40	0.91	44.47	8.5406	76.82
60	0.74	37.79	6.8974	73.88



Tensile strength curve

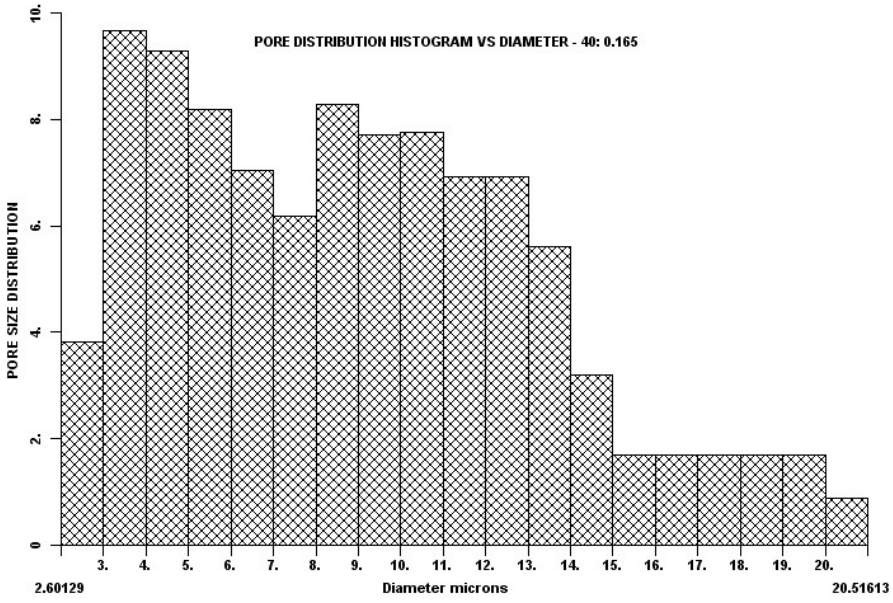
Melt Blown Process

The 2nd & 3rd Experiment

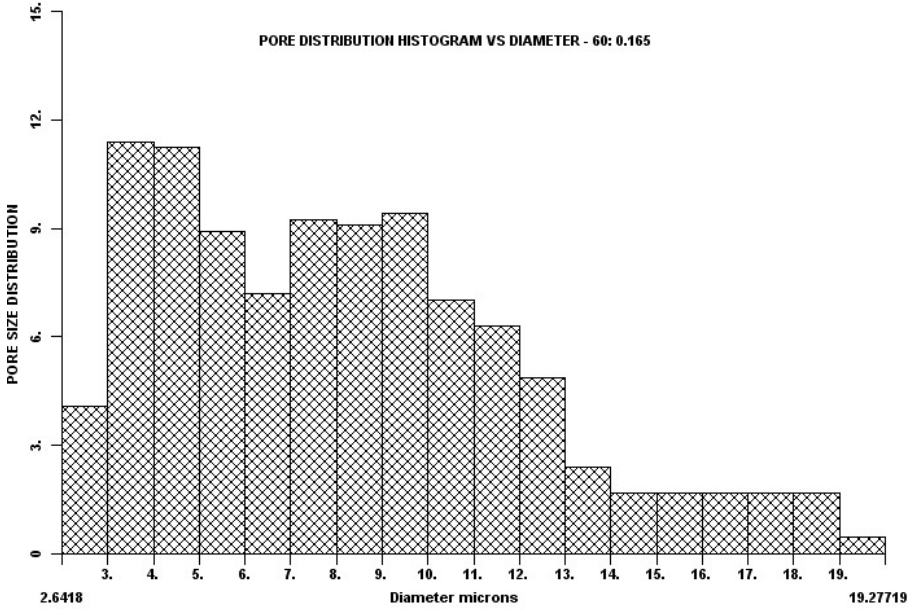
◆Pore Size Test

Instrumentation: Capillary Flow Porometer

Content of PP-g-NDAM (%)	Thickness (mm)	Mean Flow Pore Diameter（μm）	Bubble Point Pore Diameter（μm）
40	0.91	8.70	20.52
60	0.74	7.79	19.28



40% PP-g-NDAM



60% PP-g-NDAM

Melt Blown Process

The 2nd & 3rd Experiment

◆Filtration Efficiency Test

- Instrumentation：TSI8130
- Particulate matter ： Nacl
- Particle diameter ： 0.26um

Sample	Flow (L/min)	Respiratory resistance (mmH_2O)	Filtration efficiency (%)
Pure PP	32	1.81	35.16
40% pp-g-NDAM	32	1.1	30
60%pp-g-NDAM	32.1	1.33	28.77

Sample	Flow (L/min)	Respiratory resistance (mmH_2O)	Filtration efficiency after electret 30kv (%)
Pure PP	32	1.9	84.04
40% pp-g-NDAM	32	1.1	79.56
60% pp-g-NDAM	32.1	1.33	77.41

Melt Blown Process

The 2nd & 3rd Experiment

- ***Mechanism of filtration***

➢ Colliding

➢ Electrostatic adherence

➢ Inertial impaction

➢ Diffusion effect

➢ Gravitational

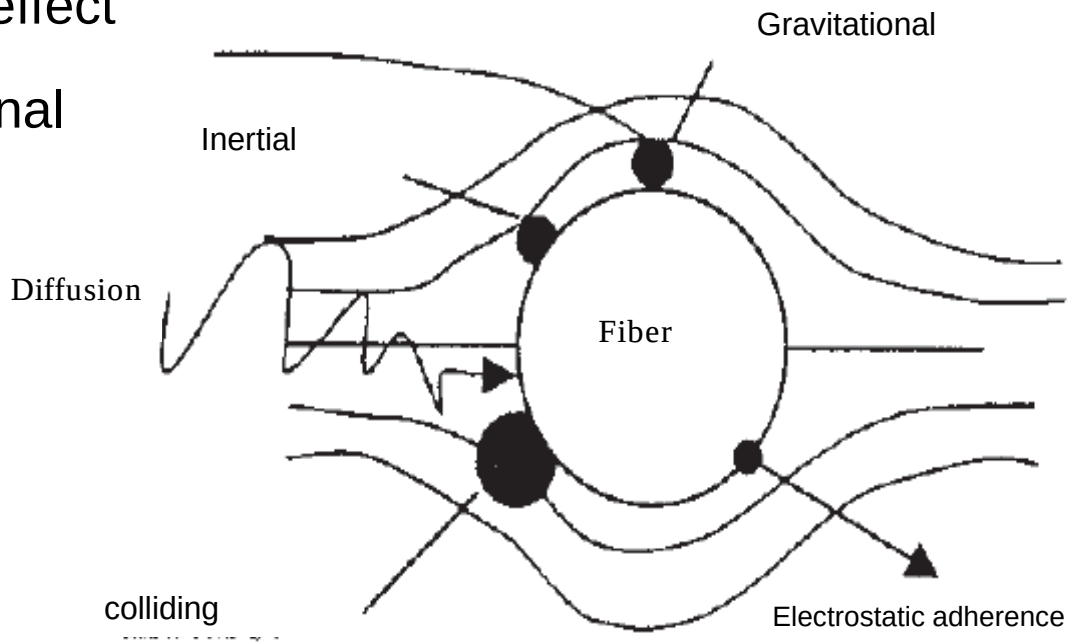
Factors affect filtration efficiency

➢Diameter of fibers

➢Mean Flow Pore Diameter

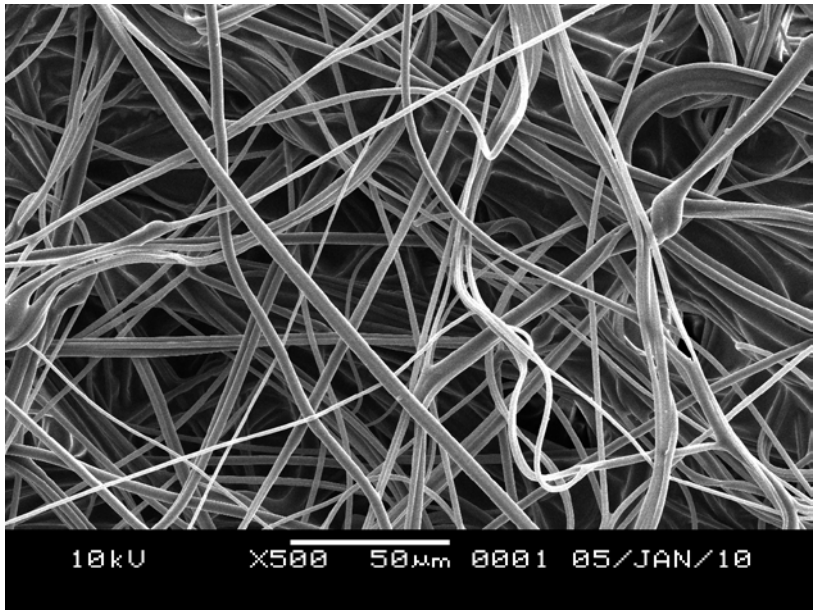
➢Electret

➢Thickness

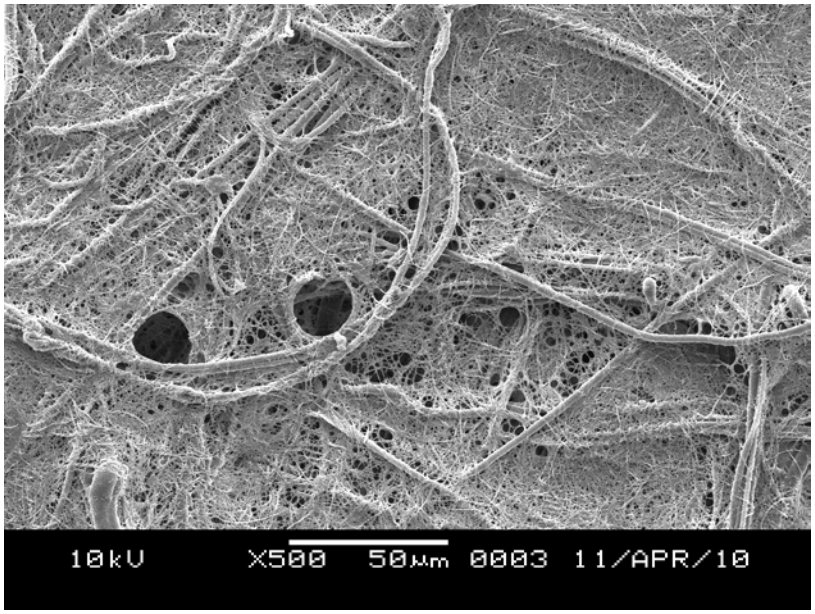


Melt Blown Process

- *Respiratory resistance*
  - Medical respiratory resistance ≤35mmH_2O (GB2626-2006)
  - Melt blown of Medical face mask respiratory resistance :1~6 mmH_2O



x500 Pure PP melt blown

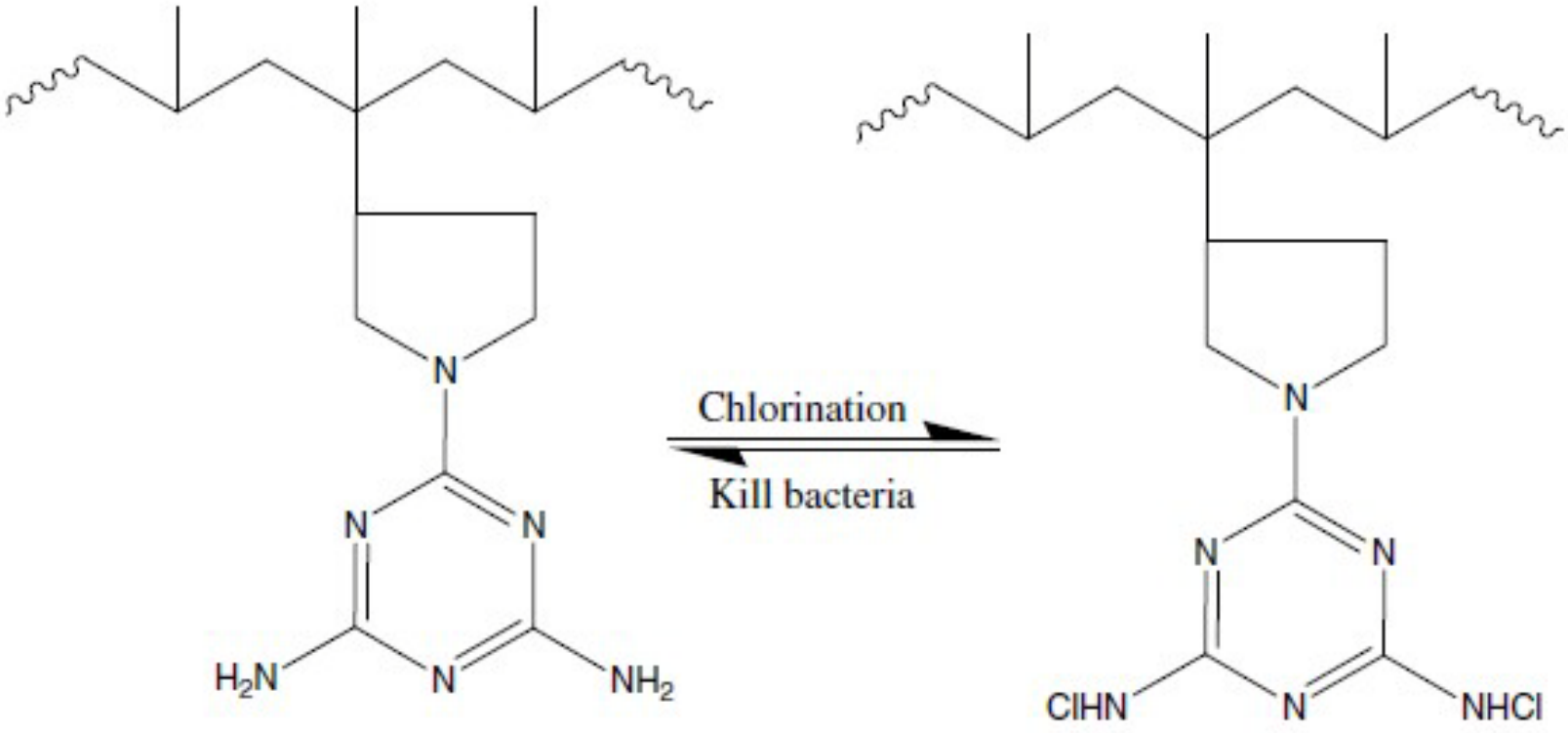


Melt blown after nano coating

Resistance	5.4mmH_2O	→	151.9mmH_2O
Filtration efficiency	99.92%		95.6%

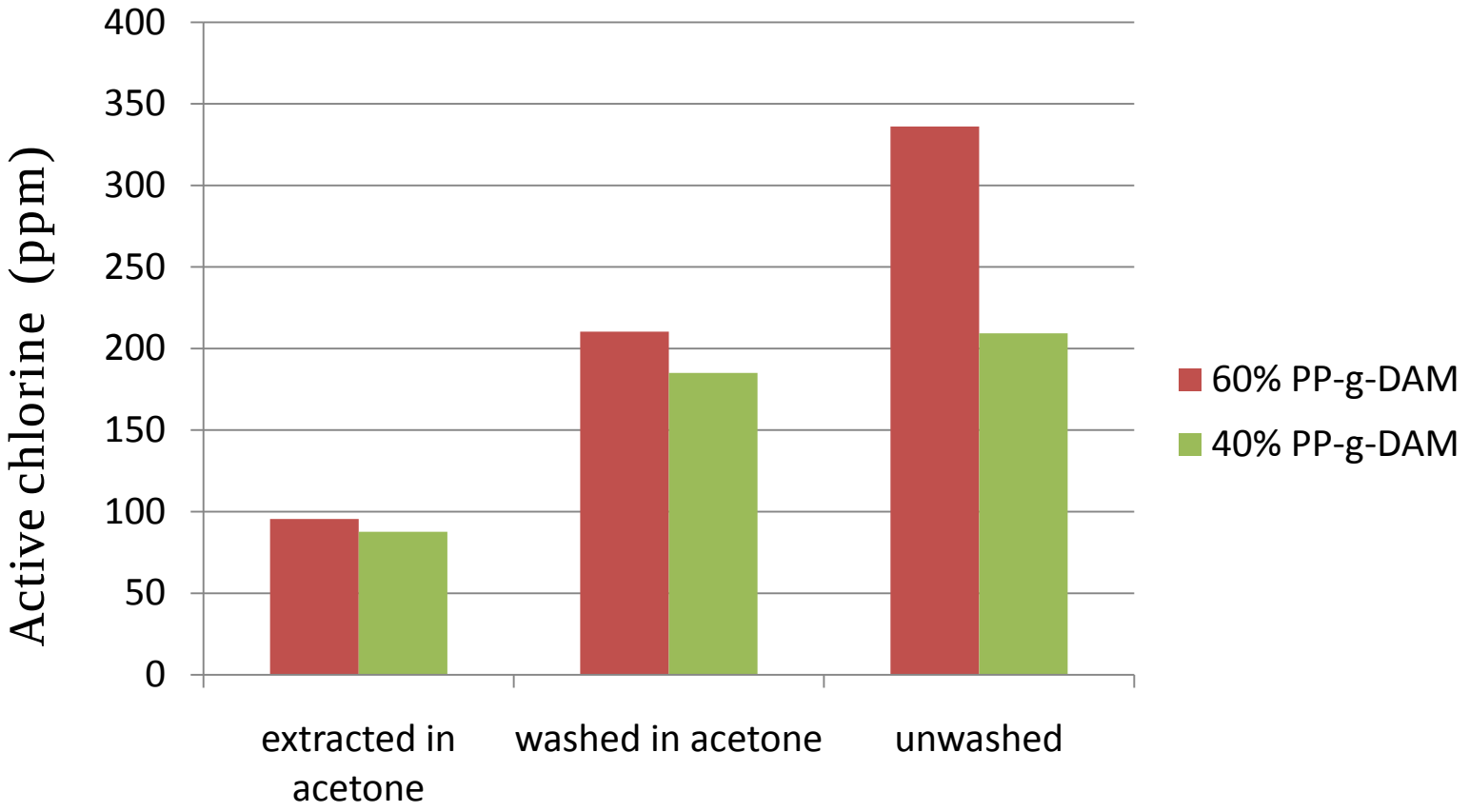
Evaluation of Antibacterial Properties

Mechanism of Antibacterial PP-g-NDAM



Scheme 3. Simplified mechanism of biocidal polypropylene.

Evaluation of Antibacterial Properties



PP-g-DAM meltblown	extracted in acetone	washed in acetone	unwashed
60% PP-g-DAM	95.49	210.4	336.07
40% PP-g-DAM	87.65	185.04	209.32

Evaluation of Antibacterial Properties

Antibacterial result of cleaned samples

S.Auraus (c=1x10^5)

		x10^0	x10^1	x10^2	x10^3	
40%	Control	8	86	10.5	2	61%
	S	8	65.5	6.5	0.5	
60%	Control	8	105	12.5	2.5	73%
	S	8	49.5	5	0.5	

E.Coli (c=3.0x10^5)

		x10^0	x10^1	x10^2	x10^3	
40%	Control	8	233.5	46	5.5	27%
	S	8	220.5	33.5	4	
60%	Control	8	275	68.5	6.5	69%
	S	8	218	24.5	1.5	

Standard: AATCC100

Conclusion

- The Melt-blown web forming technology of PP-g-NDAM is feasible
- Key technology: control of fiber fineness distribution and fiber web evenness, besides, electret processing can increase filtration efficiency without increasing respiratory resistance
- Anti-bacterial mask has a broad market prospect.
- Control the spinning temperature of melt blown process
- Raw material affects the property of modified PP fabric
- The best property: 60% PP-g-NDAM
- The grafting ration affects the antibacterial

Prospect

◆***Optimize Melt Blown Technology***

- Decrease the temperature of melt blown technology
- Decrease Fiber fineness ≤2μm
- Increase Filtration of Melt Blown Materials＞90%
- Improve the mechanical properties

◆***Antibacterial Properties***

- Improve the grafting ration of PP and NDAM
- Increase Antibacterial rate ≥99.9%

◆***Realizing industrialization of face mask***

The End

Thank you!