Development of Nanofiber Based Colorimetric Sensors for Detection of Fish Freshness

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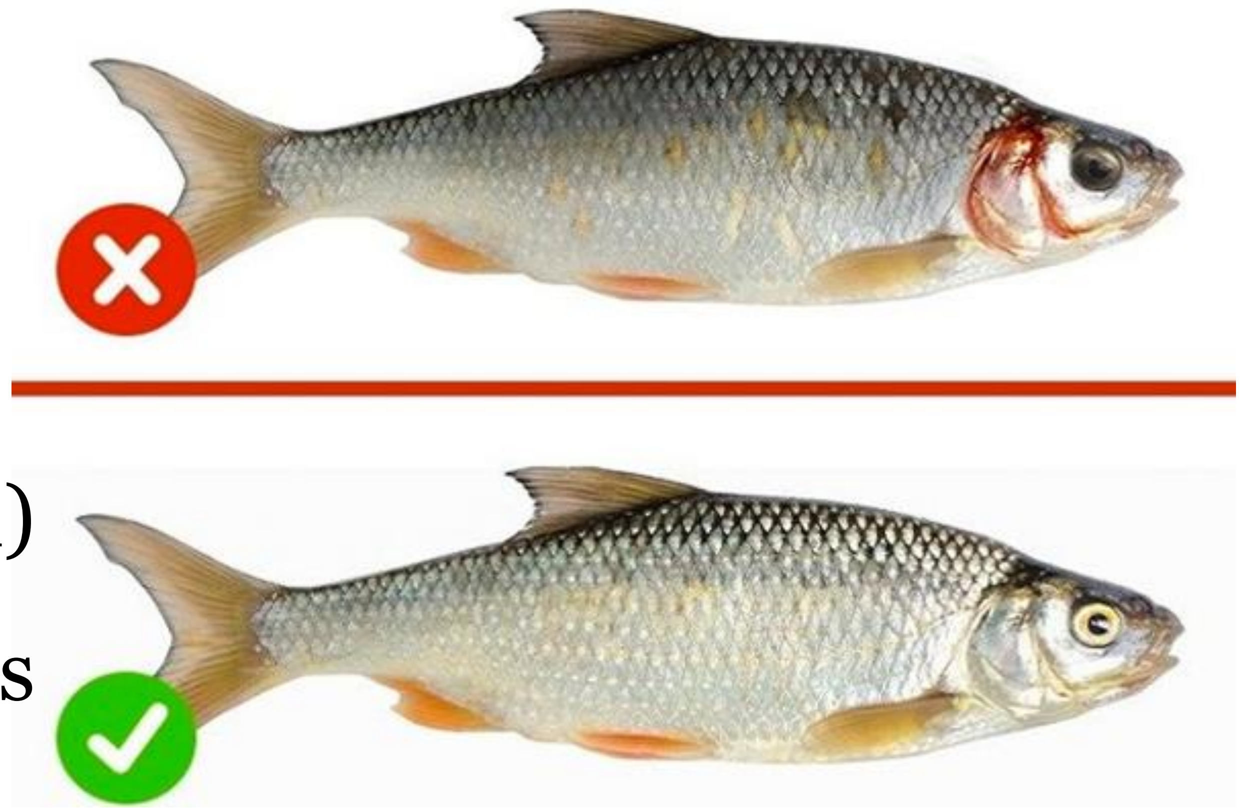
Indicators of fish freshness

- Smell
- Eyes
- Gills
- Texture (Flesh)
- Fins and Scales



Quality indices classification

- **Total Volatile Basic–Nitrogens (TVB-N)**
- Nucleotides
- Lipid oxidation product

- Trimethylamine (TMA)
- Dimethylamine (DMA)
- Ammonia (NH_3)

Reduction reactions of TMAO

$AH_2 + TMAO \rightarrow A + TMA + H_2O$

$CH_3CHOHCOOH + TMAO \rightarrow CH_3COCOOH + TMA + H_20$

Lactic Acid **Pyruvic Acid**

$CH_3COCOOH + TMAO \rightarrow CH_3COOH + TMA + CO_2$

Pyruvic Acid **Acetic Acid**

Sensors for detection of fish freshness

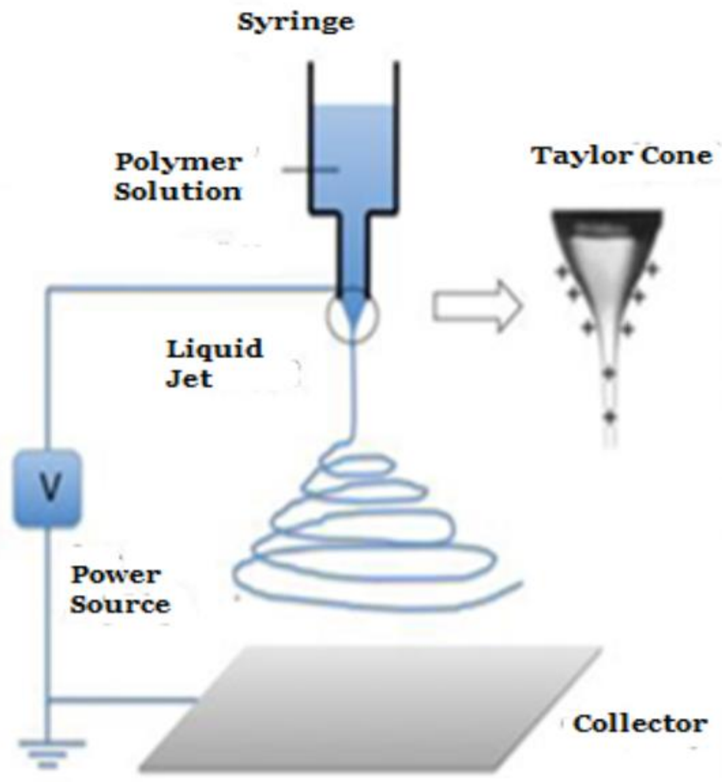
Sensors have been developed that are sensitive to

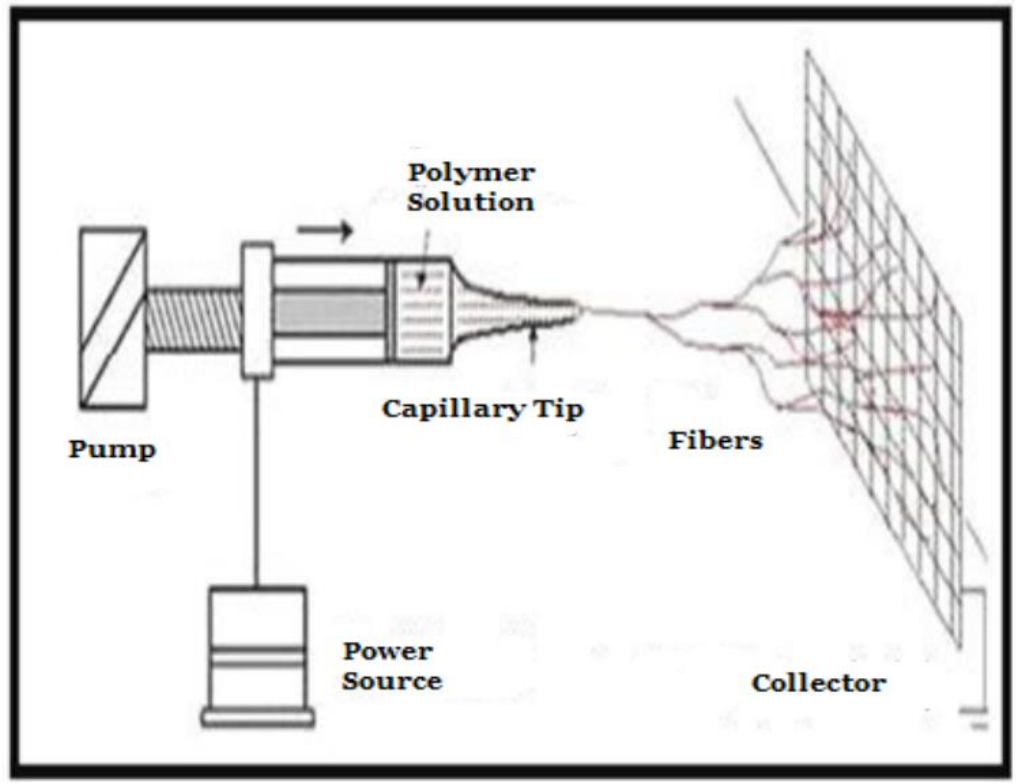
- volatile nitrogen compounds,
- pH changes,
- hydrogen sulfide and
- various microbial metabolites.

pH values of fish

- pH of the newly caught fish → **6.0 – 6.5**
- Upper limit of consumability → **6.8 – 7.0**

A typical electrospinning setup



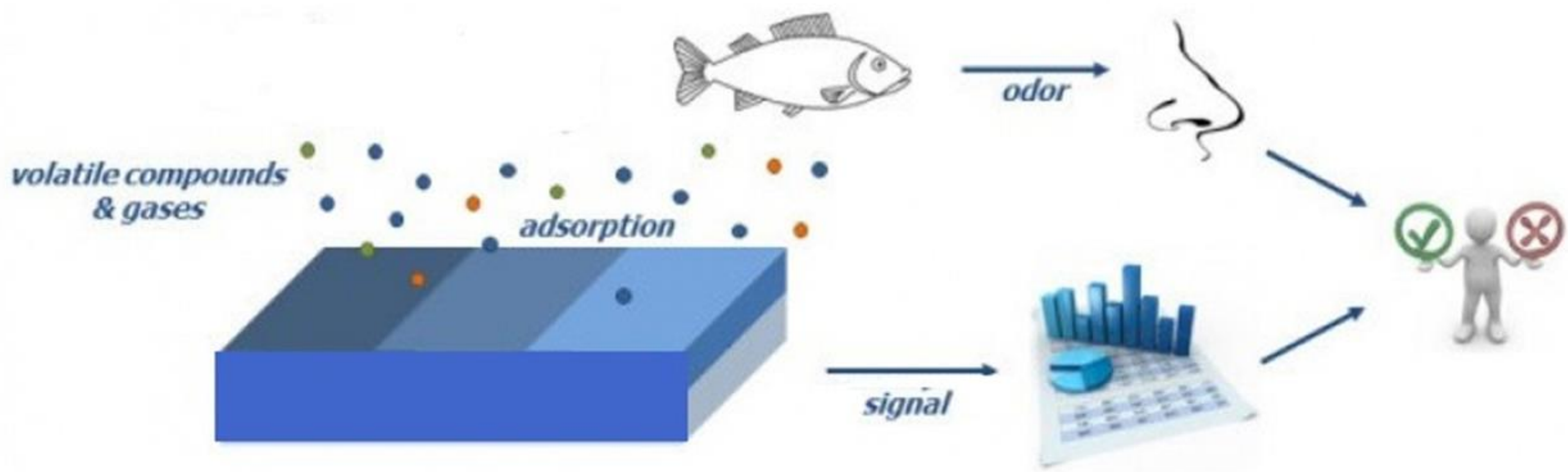


Advantages of Electrospinning

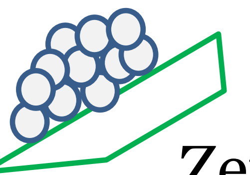
- Inexpensive setup
- Ability to control many factors, such as the fiber diameter and composition
- High surface area to volume ratio
- Ease of material combination

The aim of this study

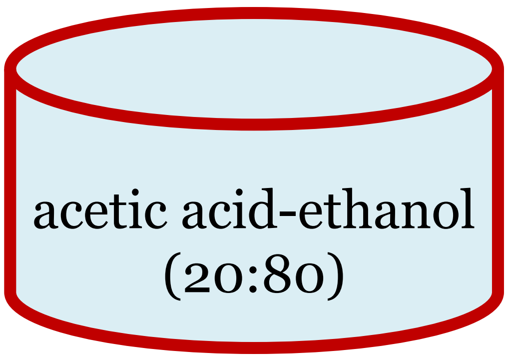
- To produce a sensor by electrospinning method for the detection of TVB-N resulting from the spoilage of fish.



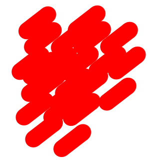
Materials and methods



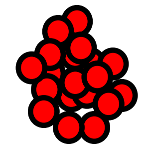
Zein



36% zein solution

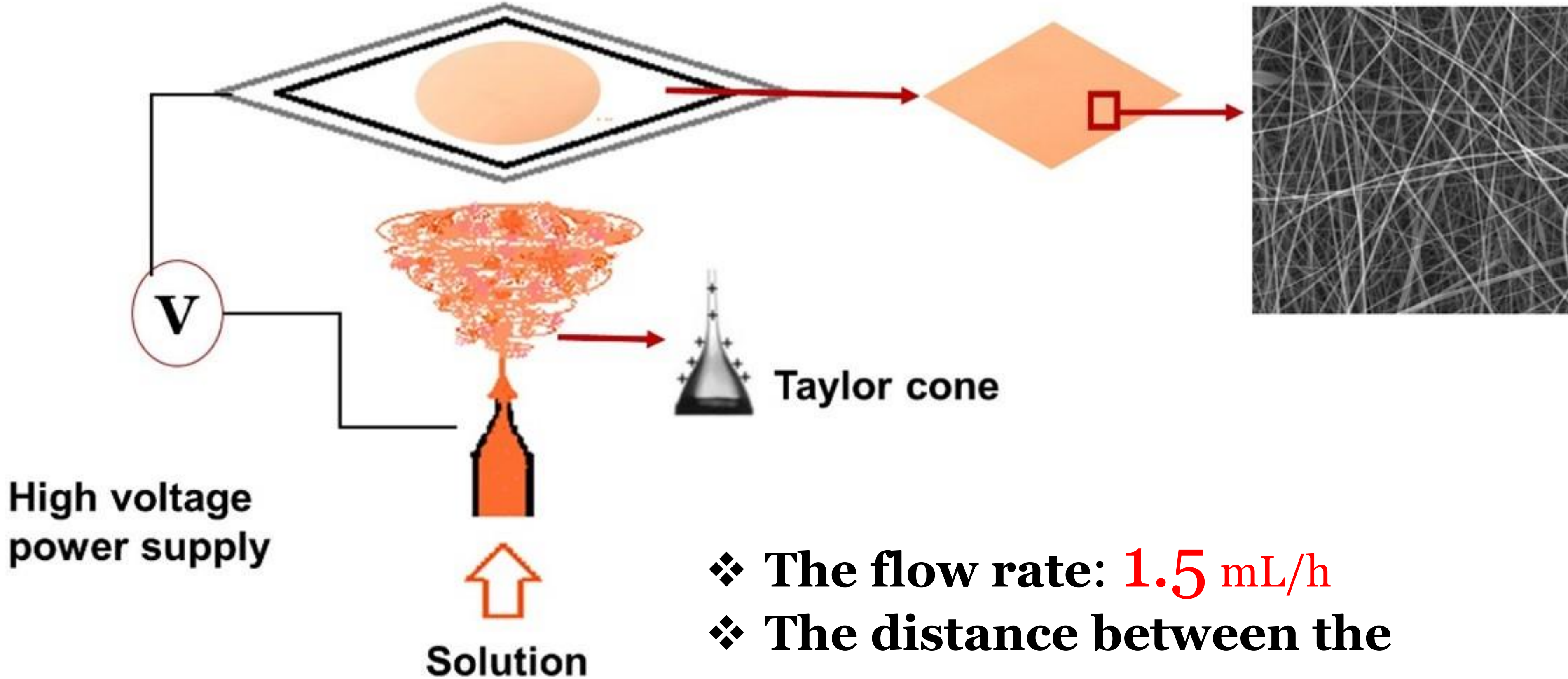


Methyl Red



Phenol Red

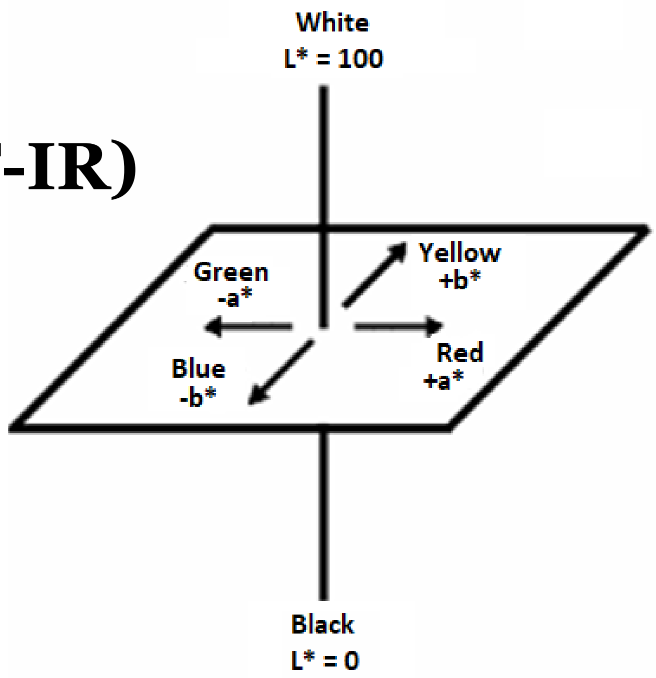
MR (%)	PR (%)
100	0
50	50
25	75
0	100



- **The flow rate:** 1.5 mL/h
- **The distance between the collector and the needle:** 20 cm
- **The applied voltage:** 19 kV

Electrospinning setup for the production of nanofiber based sensors

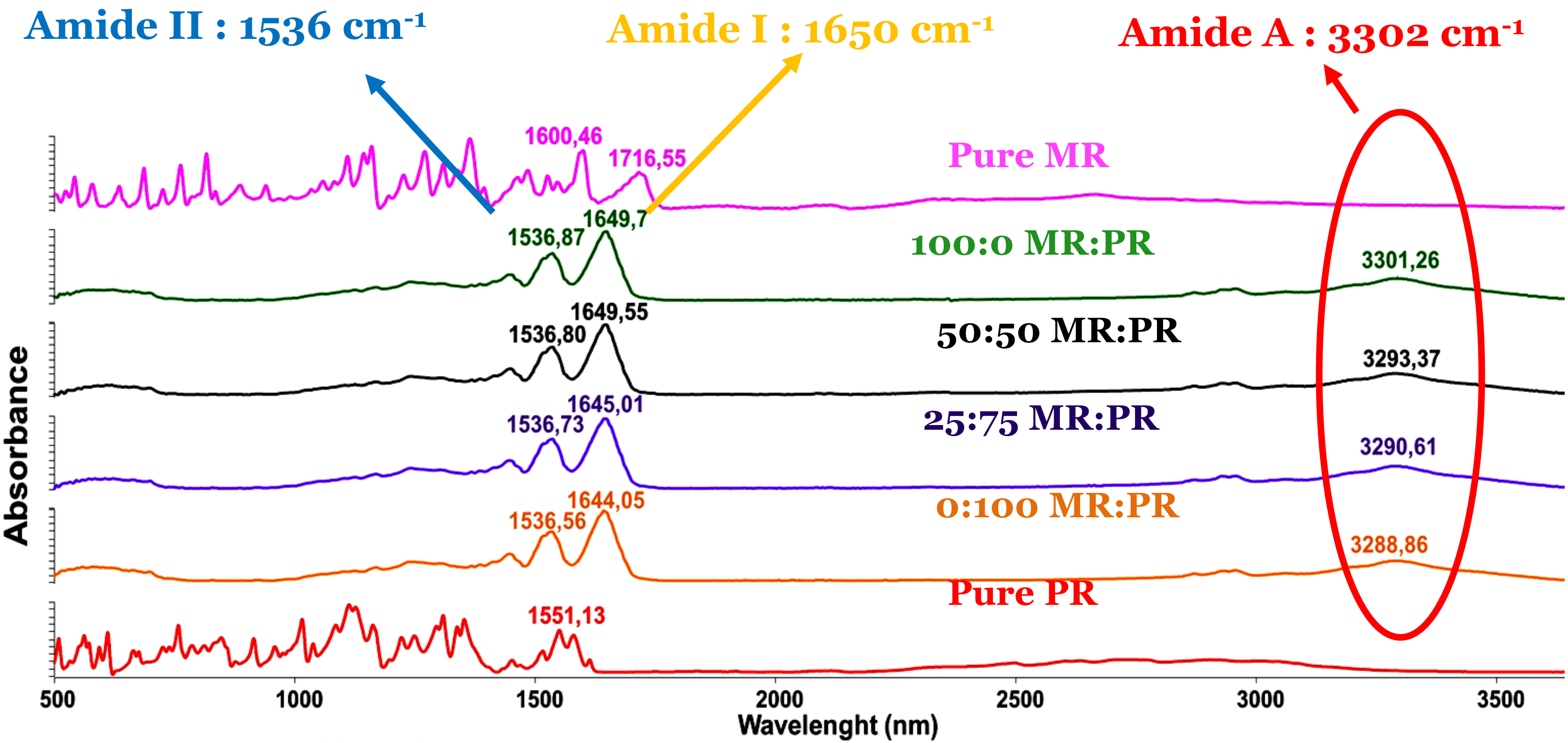
- **Scanning electron microscope (SEM)**
- **Fourier transform infrared (FT-IR) spectrophotometer**
- **Colorimetric analysis**



The total color change (ΔE) value was calculated using the following formula:

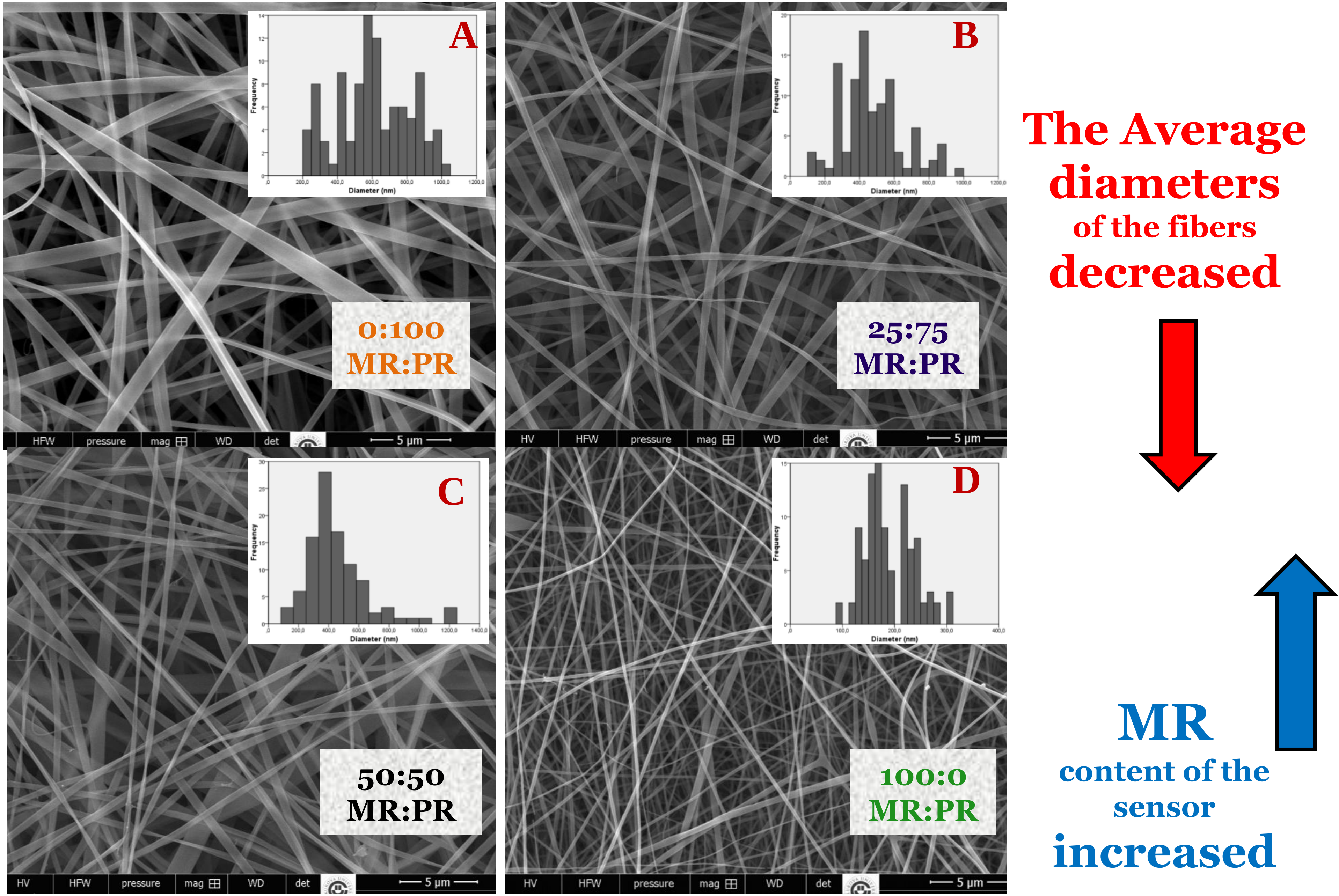
$$\Delta \mathbf{E} = \left[\left(\Delta \mathbf{L}^*_{\mathbf{sensor}_{1,2}}\right)^2 + \left(\Delta \mathbf{a}^*_{\mathbf{sensor}_{1,2}}\right)^2 + \left(\Delta \mathbf{b}^*_{\mathbf{sensor}_{1,2}}\right)^2\right]^{0.5}$$

Results



FT-IR spectra of fish freshness sensors produced by electrospinning with pure MR and PR.

The FTIR results showed that the interaction between MR, PR and zein affected Amide A and Amide I which were specific for the protein bands contained in the zein polymer.



SEM images and diameter distributions of fish freshness sensor produced by electrospinning. The MR:PR ratios are: A) 0:100, B) 25:75, C) 50:50, D) 100:0

Fresh fish

Fresh fish

There **was no change in the color of sensor** placed in the jar containing **fresh fish** because the amount of TVB-N released from fresh fish was very small.

However, the color of MR-containing sensors **changed from orange to yellow** due to TVB-N released from **spoiled fish**.

Spoiled fish

Spoiled fish

When the MR content of the sensors increased from 25 to 100%, the response time of the sensor also increased from **95 to 153 s.**

The response times of sensors, pH values and chromaticity of the sensor in response to fresh and spoiled fish.

	MR (%)	PR (%)	pH	L^*	a^*	b^*	ΔE	The response time of the sensor (s)
Fresh fish	100	0	6.04	85.86	13.36	5.84	-	-
	50	50	6.04	85.96	8.36	9.96	-	-
	25	75	6.04	85.59	8.75	16.08	-	-
	0	100	6.04	91.32	-3.43	16.19	-	-
Spoiled fish	**100**	0	6.86	88.89	6.66	11.59	9.33	**153.7**
	50	50	6.86	87.46	4.05	14.94	6.75	**141.6**
	25	75	6.86	86.65	3.91	20.73	6.72	**95.0**
	0	100	6.86	91.57	-3.38	16.09	0.27	-

Conclusions

❖The most important feature of the sensors developed in this study were that it did not need to be stored with the fish for days to determine the freshness of the fish.

Fresh fish

Spoiled Fish

- ❖ To detect the spoilage of the fish, it was enough to put the sensor in a jar where it could come into contact with the TVB-N which released from the fish and wait a short time for the color change.
- ❖ As a result, the developed fish freshness sensor may help to produce new sensors for food safety.

Acknowledgement

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“Science is the most reliable guide for civilization, for life, for success in the world.”

K. Atatürk

Thanks!

Any questions?