## Analysis of Factors Affecting the Gloss of Titanium Dioxide in Coatings

**Abstract:** Aiming at the differences in the application performance of titanium dioxide at home and abroad, the morphology of different titanium dioxide products including GT1, GT2 and MT were analyzed by SEM, TEM, EDS, XPS and FTIR. The influencing factors of the glossiness of titanium dioxide in coatings were studied. The results show that the MT particle size is centrally distributed in the range of 0.1-0.5 μm, with a mean particle size of 0.249 μm. The MT surface envelope has a high degree of integrity, with the thickness of the envelope layer ranging from 1.2 to 4.5 nm. The MT surface has a high hydroxyl content, with low oil absorption and specific surface area, and good dispersion in the coating. This is because the surface structure of foreign titanium dioxide MT is better than that of GT1 and GT2, so that the gloss of MT in coatings is higher than that of domestic titanium dioxide products GT1 and GT2.

**Key words:** titanium dioxide, surface composition, gloss, envelope integrity, particle size

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### 1. Introduction

$TiO_2$ is the most widely used white pigment in coatings (10–30% content), rubber, plastics, and paper. Gloss is a critical quality metric for coatings, yet China—despite being the largest $TiO_2$ producer (3.861 million tons in 2022)—relies on imports for high-end products due to performance gaps.

**Prior Research**:

- $Al_2O_3$/$SiO_2$/$ZrO_2$ coatings improve $TiO_2$ dispersion and UV resistance [5–8].
- Organic coatings (e.g., polystyrene) enhance stability [9].

- Ternary Si-Al-Zr coatings achieve international-grade gloss [10].

**Innovation**: This study systematically links $TiO_2$ surface structure (particle size, coating integrity, hydroxyl content) to gloss performance, providing actionable insights for domestic product development.

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## 2. Experimental

### 2.1 Materials

- GT1, GT2: Domestic chloride-process rutile $TiO_2$
- MT: Imported $TiO_2$ (Millennium Inorganic Chemicals)

### 2.2 Characterization

| Technique | Instrument | Parameters |
|---|---|---|
| SEM/TEM | Thermo Scientific APREO2C, JEOL JEM-F200 | 40,000× magnification |
| FTIR | Shimadzu IRTracer-100 | KBr pellet, 10 MPa pressure |
| XPS | ThermoFisher ESCALAB Xi+ | C 1s ref. 284.8 eV |

**Gloss Measurement**:

1. Prepare 18% $TiO_2$ coating samples.
2. Apply films via automatic coater.
3. Measure 60° gloss using glossmeter.

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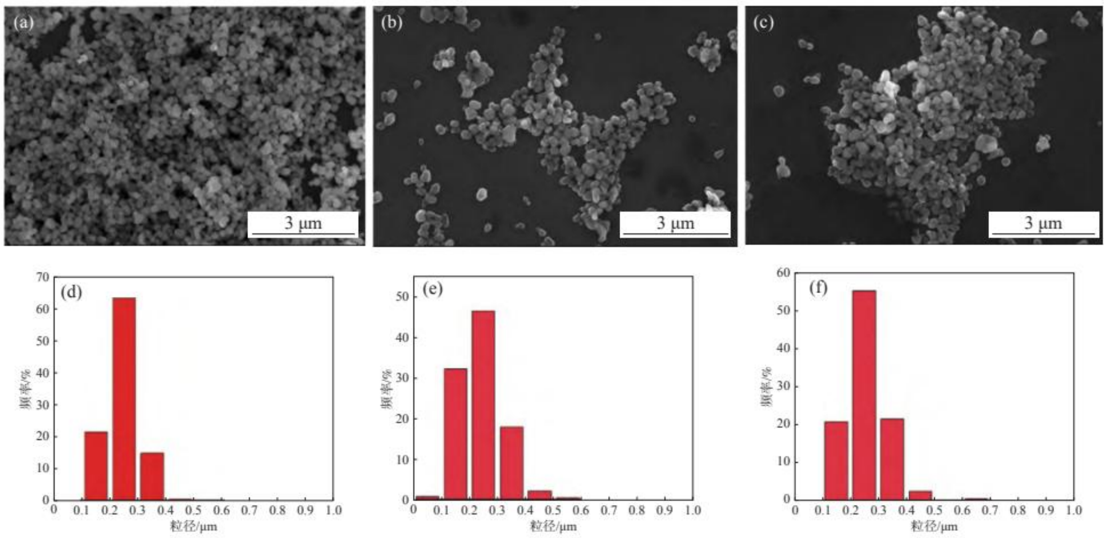
## 3. Results and Discussion

### 3.1 Particle Size Distribution

SEM reveals:

- MT has the most uniform particle distribution (0.1–0.5 μm).
- GT2 shows aggregation and broader size dispersion (0–0.6 μm).

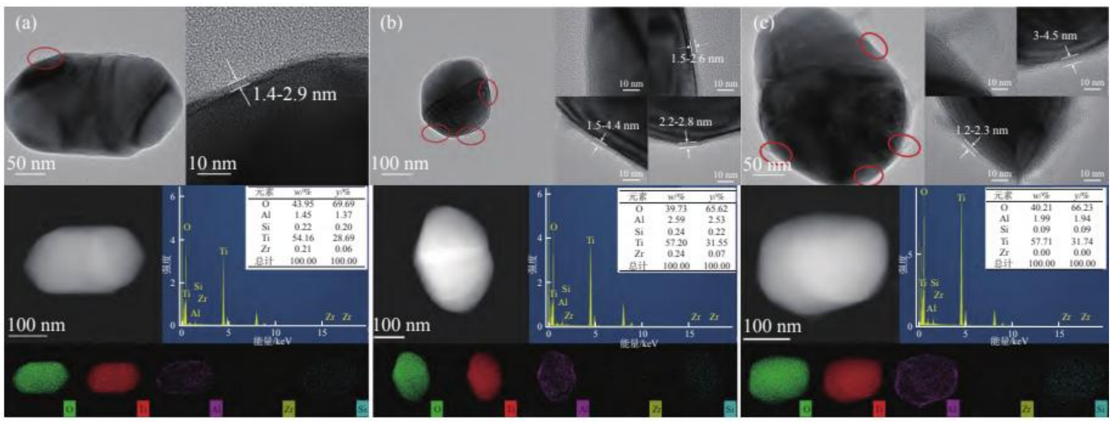



(a)(d): GT1; (b)(e): GT2; (c)(f): MT

### 3.2 Surface Coating Integrity

TEM/EDS analysis:

- **MT**: Continuous, dense $Al_2O_3$ coating (3–4.5 nm) with homogeneous precipitation.
- **GT1/GT2**: Incomplete coatings (1.4–2.9 nm) with uneven thickness.

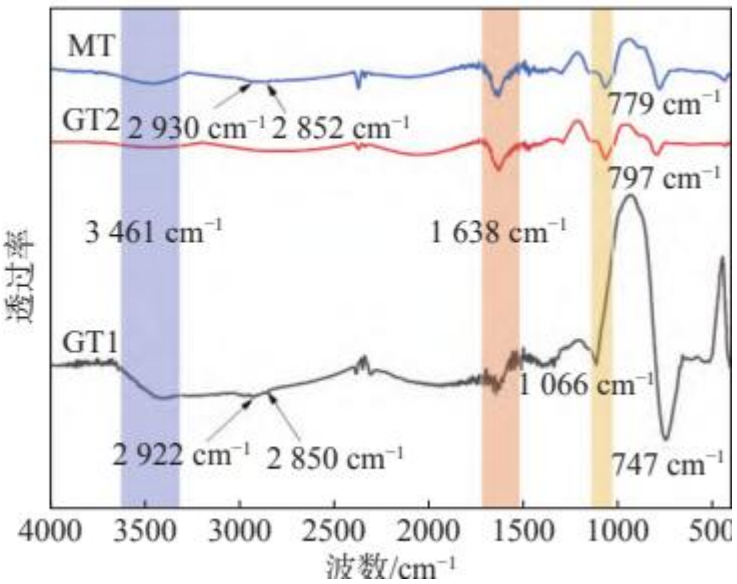


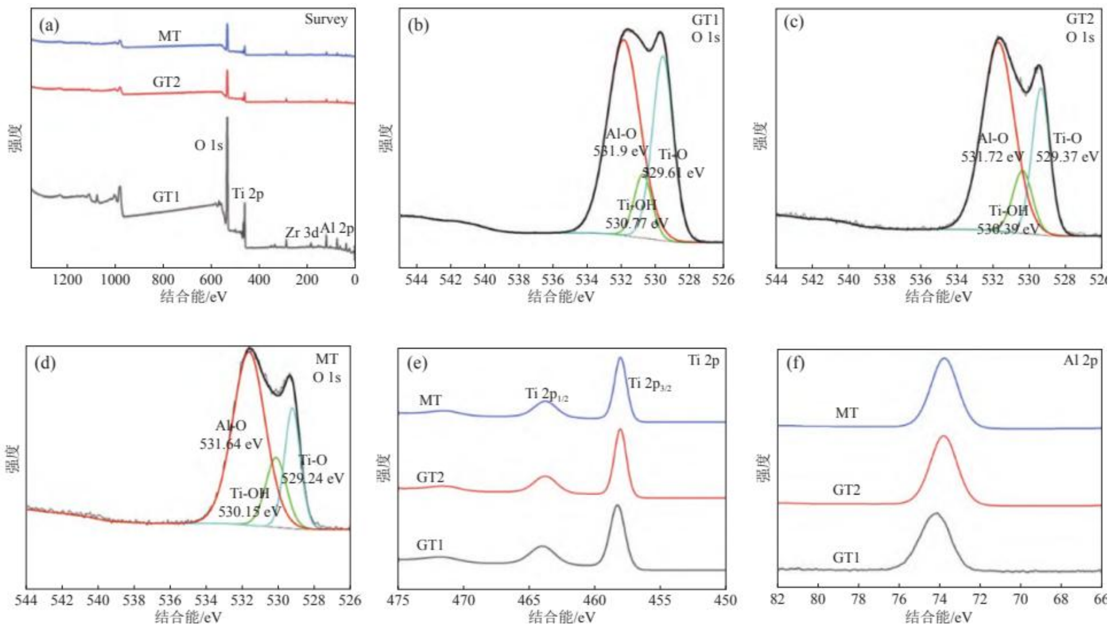

(a): GT1; (b): GT2; (c): MT

### 3.3 Surface Chemistry

**FTIR/XPS Findings**:

- Hydroxyl content: MT ($3.19/nm^2$) > GT2 (3.00) > GT1 (2.37).
- Al-O-Ti bonding confirmed at 1066 $cm^{-1}$ (FTIR) and 531.9 eV (XPS O 1s).
- Organic treatments (C-H peaks at 2922 $cm^{-1}$) enhance MT/GT1 dispersion.




### 3.4 Gloss Performance

**Key Trends**:

1. Gloss ranking: **MT > GT1 > GT2** at 18% concentration.
2. MT maintains stable gloss across concentrations due to coating integrity.
3. High surface area (GT1: 15.5 m²/g) correlates with lower gloss.

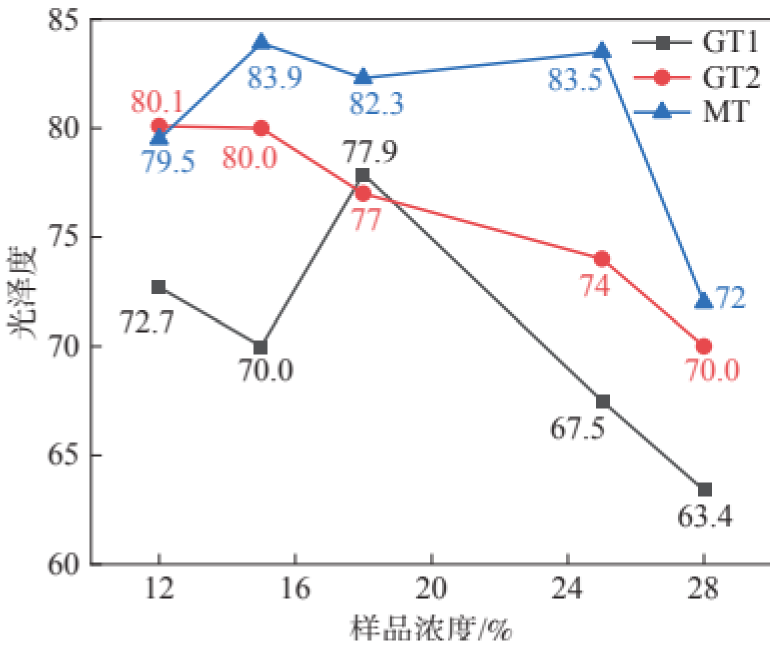



**Table 1** Surface hydroxyl density

| Sample | Hydroxyl Groups ($nm^{-2}$) |
|---|---|
| GT1 | 2.37 |
| GT2 | 3.00 |
| MT | 3.19 |

**Table 2** Physical properties

| Sample | SSA ($m^2/g$) | Oil Absorption (g/100g) | Dispersion (μm) |
|---|---|---|---|
| GT1 | 15.5 | 19.1 | 11.7 |
| GT2 | 13.9 | 19.0 | 18.3 |
| MT | 12.1 | 19.7 | 10.0 |

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### 4. Conclusions

1. **Optimal Particle Size**: 0.25 μm average size maximizes light scattering.
2. **Coating Integrity**: Continuous $Al_2O_3$ layers (1.2–4.5 nm) boost gloss.
3. **Surface Hydroxyls**: Higher OH content ($\geqslant 3/nm^2$) improves dispersion.
4. **Production Strategy**: Domestic manufacturers should prioritize:

- Precise particle size control
- Complete inorganic/organic surface coatings
- Reduced specific surface area

**Outlook**: This study provides a roadmap for developing high-gloss $TiO_2$ to replace imports.