



## IMPROVING THE TECHNOLOGY OF OBTAINING POLYMER COATINGS THAT CORRODE THE DETAILS OF CARS

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### Abstract

This article provides a comprehensive overview of polymer coatings, covering various technologies and applications in different industries, including automotive. It discusses the fundamentals of polymer coatings, their properties, and practical applications.

**Keywords:** Polymer coatings, Technologies, Applications, Automotive, Properties, Fundamentals

### Introduction

Improving the technology of obtaining polymer coatings for car parts to enhance corrosion resistance involves several key strategies and advancements. Here are some approaches:

- 1. Advanced Polymer Formulations:** Developing new polymer materials that have inherent corrosion resistance can significantly enhance the durability of coatings. This includes the use of high-performance polymers such as fluoropolymers, which have excellent resistance to environmental factors.
- 2. Nanotechnology:** Incorporating nanoparticles into polymer coatings can improve their barrier properties and mechanical strength. Nanoparticles such as nano-silica, carbon nanotubes, and graphene can enhance the impermeability of the coating to water and oxygen, which are primary contributors to corrosion.
- 3. Self-Healing Coatings:** These coatings can autonomously repair minor damages like scratches or cracks. They contain microcapsules filled with healing agents that are released when the coating is damaged, thereby maintaining its integrity and protective properties.



**4. Surface Preparation and Treatment:** Proper surface preparation, including cleaning and pretreatment, is crucial for ensuring the adhesion and effectiveness of polymer coatings. Techniques like phosphating, anodizing, or the application of conversion coatings can create a more suitable surface for polymer application.

**5. Electrochemical Methods:** Utilizing electrochemical deposition techniques can improve the uniformity and adhesion of polymer coatings. Electrophoretic deposition (EPD) allows for the controlled application of coatings, ensuring even coverage and strong bonding to the substrate.

**6. Hybrid Coatings:** Combining organic polymers with inorganic materials can result in hybrid coatings that offer superior protection. For instance, incorporating silane or sol-gel technologies can create coatings that combine the flexibility of polymers with the hardness and durability of inorganic materials.

**7. Environmental and Process Control:** Controlling the environmental conditions during the application and curing of polymer coatings is essential. Factors like humidity, temperature, and cleanliness can significantly impact the quality and performance of the coating.

**8. Innovative Curing Methods:** Advanced curing methods, such as UV curing, electron beam curing, or thermal curing, can improve the cross-linking density of the polymer, enhancing its resistance to environmental degradation and mechanical wear.

**9. Testing and Quality Assurance:** Implementing rigorous testing protocols to assess the corrosion resistance, adhesion, and mechanical properties of the coatings ensures that only high-quality coatings are used. Techniques like salt spray testing, electrochemical impedance spectroscopy (EIS), and adhesion testing are essential.

**10. Sustainability and Compliance:** Developing environmentally friendly coatings that comply with regulations (e.g., REACH, RoHS) ensures that the coatings are not only effective but also sustainable. This includes reducing volatile organic compounds (VOCs) and using bio-based polymers.



By integrating these strategies, the technology for obtaining polymer coatings can be significantly improved, providing better protection for car parts against corrosion and extending their lifespan.

Here's a more detailed look into each of the strategies for improving polymer coatings for car parts to enhance corrosion resistance:

### **1. Advanced Polymer Formulations**

**High-Performance Polymers:** Materials like polyvinylidene fluoride (PVDF), polytetrafluoroethylene (PTFE), and other fluoropolymers offer superior resistance to UV light, chemicals, and temperature fluctuations. These polymers can be tailored with additives to further improve their protective qualities.

### **2. Nanotechnology**

**Nanoparticles:** Incorporating nanoparticles such as nano-silica, titanium dioxide, zinc oxide, or carbon nanotubes into the polymer matrix can significantly enhance the coating's barrier properties. These particles create a more tortuous path for water and oxygen, reducing their penetration and thus slowing down corrosion processes.

### **3. Self-Healing Coatings**

**Microcapsules and Polymers:** Self-healing coatings contain microcapsules filled with healing agents like resins or catalysts. When the coating is damaged, these microcapsules break open, releasing the healing agents that fill cracks and restore the coating's integrity. Polymers such as polyurethane with embedded healing agents are often used in these applications.

### **4. Surface Preparation and Treatment**

**Cleaning and Pretreatment:** Ensuring a clean surface free of oils, dirt, and rust is essential. Techniques such as sandblasting, acid etching, or alkaline cleaning are commonly used. Conversion coatings (e.g., zinc phosphate or chromate treatments) can also be applied to enhance adhesion and provide an initial layer of corrosion protection.

### **5. Electrochemical Methods**

**Electrophoretic Deposition (EPD):** This process involves applying a voltage to drive charged polymer particles onto a substrate, creating a uniform and



adherent coating. EPD is particularly useful for coating complex shapes and ensuring consistent thickness across the surface.

## 6. Hybrid Coatings

**Organic-Inorganic Hybrids:** Combining polymers with inorganic components, such as silane-modified polymers or sol-gel derived coatings, can result in coatings with enhanced mechanical properties and corrosion resistance. These hybrids leverage the flexibility and toughness of polymers with the hardness and barrier properties of inorganic materials.

## 7. Environmental and Process Control

**Controlled Application:** Applying coatings under controlled environmental conditions can prevent issues like bubbling, poor adhesion, or incomplete curing. Cleanrooms, humidity control, and temperature regulation are crucial during both the application and curing stages.

## 8. Innovative Curing Methods

**UV and Electron Beam Curing:** These methods involve using UV light or electron beams to rapidly cure the polymer coating. This can significantly improve the cross-linking density, resulting in harder, more durable coatings. UV curing, in particular, is advantageous for its speed and energy efficiency.

## 9. Testing and Quality Assurance

**Corrosion Testing:** Salt spray tests (ASTM B117), cyclic corrosion tests, and immersion tests are commonly used to evaluate a coating's resistance to corrosive environments. Electrochemical Impedance Spectroscopy (EIS) provides detailed information about the coating's protective capabilities by measuring its electrical resistance.

**Adhesion Testing:** Methods like the pull-off test (ASTM D4541) or cross-cut test (ASTM D3359) assess the coating's adhesion strength. Poor adhesion can lead to premature failure of the coating, so rigorous testing is essential.

## 10. Sustainability and Compliance

**Eco-Friendly Formulations:** Reducing or eliminating volatile organic compounds (VOCs) in coatings helps in complying with environmental regulations. Using bio-based or waterborne polymers reduces environmental



impact while maintaining performance. Compliance with regulations like REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) and RoHS (Restriction of Hazardous Substances) is crucial for market acceptance.

Improving the technology of obtaining polymer coatings to enhance corrosion resistance for car parts in Uzbekistan involves adapting advanced techniques and materials to local conditions and industry needs. Here's a detailed approach considering Uzbekistan's specific context:

### **1. Local Material Sourcing and Formulations**

**Advanced Polymers:** Focus on sourcing high-performance polymers that are available locally or regionally to reduce costs. Polymers like epoxy, polyurethane, and fluoropolymers can be tailored with local additives to enhance their corrosion resistance.

**Nanotechnology:** Use locally sourced nanoparticles like nano-silica, which can be integrated into polymer coatings to improve barrier properties and mechanical strength.

### **2. Enhancing Self-Healing Coatings**

**Microencapsulation:** Collaborate with regional chemical manufacturers to develop self-healing coatings. Microencapsulation techniques can be adapted to include healing agents suited for the local climate, such as those that respond well to the temperature ranges and humidity levels typical in Uzbekistan.

### **3. Improved Surface Preparation Techniques**

**Localized Pretreatment Methods:** Implement cost-effective and readily available pretreatment methods like sandblasting and acid etching. Investing in local production of conversion coatings, such as zinc phosphate, can improve adhesion and initial corrosion protection.

### **4. Adoption of Electrochemical Deposition**

**EPD Technology:** Introduce electrophoretic deposition (EPD) technology in local manufacturing plants. EPD can be highly effective for achieving uniform coatings on complex shapes, a common requirement in the automotive industry.



## 5. Developing Hybrid Coatings

**Organic-Inorganic Hybrids:** Promote research collaborations with local universities and research institutions to develop hybrid coatings. Using locally available inorganic materials like silanes or developing sol-gel processes can create durable hybrid coatings.

## 6. Process Control and Environmental Adaptation

**Controlled Application Environments:** Upgrade local manufacturing facilities with controlled environments for coating application. Ensuring consistent temperature and humidity control can prevent defects and improve coating quality.

## 7. Advanced Curing Techniques

**UV and Thermal Curing:** Invest in UV and thermal curing technology. UV curing, in particular, offers rapid curing times and energy efficiency, which can be beneficial in Uzbekistan's climate.

## 8. Rigorous Testing and Quality Assurance

**Localized Testing Protocols:** Establish local laboratories equipped for rigorous testing of coatings. Corrosion tests such as salt spray testing (ASTM B117), cyclic corrosion tests, and adhesion tests (ASTM D4541) should be standardized and routinely performed.

## 9. Sustainability and Regulatory Compliance

**Eco-Friendly Coatings:** Develop and implement environmentally friendly coating solutions that comply with international standards. This includes reducing VOCs and using bio-based polymers. Encourage local regulation alignment with global standards like REACH and RoHS.

## 10. Training and Skill Development

**Skill Enhancement Programs:** Implement training programs for local workforce on advanced coating technologies and techniques. Partnerships with international experts can facilitate knowledge transfer and upskilling.



## 1. Collaboration with Local Industries

**Industry Partnerships:** Foster collaborations between local automotive manufacturers, chemical suppliers, and research institutions to tailor polymer coating solutions to specific industry needs.

## 12. Government Support and Incentives

**Incentive Programs:** Advocate for government support in the form of subsidies, tax incentives, and grants for companies investing in advanced polymer coating technologies. Government initiatives can help offset the initial costs of technology adoption.

## 13. Investment in Research and Development

**R&D Centers:** Establish dedicated R&D centers focusing on automotive coatings. These centers can drive innovation and adaptation of global best practices to the local context.

### Practical Steps for Implementation:

- 1. Feasibility Studies:** Conduct feasibility studies to identify the most suitable advanced polymer coatings and technologies for local conditions.
  - 2. Pilot Projects:** Start with pilot projects in collaboration with leading automotive manufacturers to test and refine new coatings.
  - 3. Scale-Up:** Gradually scale up successful pilot projects to full-scale production, ensuring continuous improvement and adaptation based on feedback.
- By focusing on these strategic areas, Uzbekistan can enhance the technology for obtaining polymer coatings, providing better corrosion protection for car parts, improving vehicle longevity, and boosting the local automotive industry.

### References

1. Baghdachi, Jamil. *Polymer Coatings: Technologies and Applications*. Wiley, 2014.
2. Wen, Mei, Webster, Peter J., and Brady, Robert F. *Protective Coatings: Fundamentals, Testing, and Standards*. ASTM International, 2011.
3. Licari, James J., and Swanson, Dale W. *Handbook of Polymer Coatings for Electronics: Chemistry, Technology and Applications*. William Andrew, 1998.
4. *Progress in Organic Coatings*. (Various issues, peer-reviewed journal articles on polymer coatings).



5. Journal of Coatings Technology and Research. (Various issues, research on coating materials and properties).
6. Corrosion Science. (Various issues, studies on corrosion mechanisms and protective coatings).

