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TMG News

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Take Your Pick: An Exercise in Material Selection

Richie Anfinsen and Jack DeSousa

Introduction

From the stadium rock star, to the jazz club guitarist, to the folk mandolin player or to the person breaking out a guitar around a campfire to sing Wonderwall. They all likely have one thing in common: a guitar pick. While there are many different styles of playing guitars that do not use a pick, many guitar players will find themselves in this scenario: you have picked up a guitar, you are ready to play, you reach for the guitar pick you want, but you cannot find it...you find some other guitar pick, but it is not **THE** guitar pick that you wanted to use! So what do you do? While this scenario does not stop someone from playing guitar, many non-guitar players might be surprised to learn about the vast number of different sizes, shapes, thicknesses, textures, and materials a guitar pick can be made from (**Figure 1**). It is interesting to think that in such a seemingly simple product, many different design decisions are being made that result in a variety of end products. This article will focus on the materials utilized and how they affect the ability of the finished product to create a sound that guitarists are looking for.

Figure 1 – There are many different sizes, shapes, thicknesses, texture, and materials for guitar picks.

Design and Materials

The guitar pick is a product that can greatly benefit from the unique properties of plastic materials. However, there are many other variables in the design of the pick that can affect the performance and playability:

Material - Most modern picks are manufactured from plastics. However, there are still some guitar picks that are manufactured from wood, metal, composite, and even some picks still manufactured from real tortoise shell. Plastics can provide high strength and durability while still being flexible. The visco-elasticity of plastics also allows the material to snap back into its original shape after being bent around a string. Many metal (or even wood) guitar picks are very stiff and do not bend as much around the string when plucked. However, the material is an integral part of the guitar pick that will affect the tone of the guitar because of the way the pick interacts with the guitar's strings to produce sound.

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Size - The size affects how well the pick will fit in the player's hand, and every guitar player will have a slightly different preference for how large/small of a pick they want to use.

Shape - The shape of the pointed end can be varied from fairly rounded to very sharply pointed and narrow. These two variables typically depend on whether a series of single strings are going to be plucked or whether the pick will be moved rapidly up and down all of the strings on the instrument.

Thickness - The thickness of the guitar pick is one of the most important design variables to any guitar player. The thickness will typically have the most effect on the stiffness of the pick. A very thick guitar pick will be much stiffer, and not bend nearly as much when being plucked around a string. This can be beneficial when extreme accuracy is needed and when a player does not want the pick to be very flexible. However, a thick guitar pick will need to be very tightly gripped in order to rapidly move it up and down the entire set of strings.

Texturing - The texturing on the exterior of the guitar pick mainly determines how easily a pick can be gripped when playing guitar. However, many guitar players also want to have a smooth feel on the surface of the guitar picks. Some guitar picks utilize alternating texture patterns on the surface or even holes through the thickness of the guitar pick. Other picks utilize raised molded lettering on the surface to provide some grip. Also, inks printed on the surface of the picks can provide improved grip with a relatively low profile.

Figure 2. – These guitar picks provide close-up views of the texturing, materials, and shape differences.

Given these variables, it is no surprise that the guitar pick is not represented by just one design or material **(Figure 2)**. The large disparity in designs is due in part to the target audience of these parts, which spans across multiple countries, instruments, playing styles, and talent levels. Let us focus on one decision that needs to be made during the design of this type of product: material selection. With so many variables at play, how does the design engineer select a material that will satisfy the needs of such a broad range of end users? This is a question that is asked daily for engineers that are making consumer products. While there is not one exact answer to this question, the process can be made simpler with the correct focus during the material selection process.

The first step in any material selection is to define the requirements of the part and translate that into engineering properties to focus on during the process. For the guitar pick, we are primarily focused on feel, toughness, wear, and stiffness. The primary performance-based properties would be:

- **Coefficient of Friction –** How well the guitar pick glides across the strings. However, this will also affect how slippery the pick feels in the fingers.
- **Toughness –** How well the material will withstand the quick-impact type of loads that are experienced during use.
- **Hardness –** Ability to withstand contact with metal strings.

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*The primary performance-based properties would be: **(cont.)***

- **Fatigue Resistance –** How many uses until failure occurs.
- **Flexural Modulus –** How stiff the material feels.

Given this information, we would be able to select a material that would work for the primary goals of the product. However, with plastic materials, the environment of use needs to be given special consideration due to their plastic unique properties. For example, most guitar playing occurs indoors, which would be expected to be around room temperature. However, every year artists play in Times Square during New Year's Eve, which could be at temperatures below 0° F. These types of extreme-use scenarios need to be considered during the material selection to avoid product failure and help to produce a more desirable product.

For the guitar pick some of these considerations would include:

- **Low and High Temperature Performance –** Material should perform well in both cold and hot temperatures (not undergo major thermal transitions).
- **Chemical Resistance –** The material should withstand typical oils and greases from food, as well as other residual chemicals that could remain on the hand.
- **Tone –** How the material affects the sound of the instrument.

The requirements of high stiffness, fatigue toughness, and moderate chemical resistance would typically push the material selection towards thermoplastic semi-crystalline materials. This is due to the inferior fatigue performance and poor general chemical resistance of amorphous resins. Based on the relatively low stress requirements, but moderate hardness requirements, engineering thermoplastics such as polyamide, polyesters, and polyoxymethylene would be suitable materials. However, higher-end amorphous resins such as polyetherimide (PEI) and/or thermosetting materials could also handle the performance requirements and would provide differences in tonality.

Figure 3 – FTIR Testing of guitar picks.

Current Guitar Pick Materials

Let us look at some current guitar picks from the industry and determine why the materials may have been selected. Fourier transform infrared technology (FTIR) was utilized on three different mass-produced guitar picks to determine the different types of plastic they are made from (**Figure 3)**. FTIR is a spectroscopy technique that produces an absorption (or transmission) spectrum for the test specimen. The unique bonds in the material will absorb varying amounts of infrared light at different wavelengths, and the distinctive molecular "fingerprint" for the material can be used for characterization and identification purposes.

Guitar Pick 1 provided an FTIR spectrum that was characteristic of celluloid **(Figure 4)**. Celluloid is an old plastic material that was produced from nitrocellulose and camphor. The library spectra show that the plastic is derived from nitrocellulose and a hydrocarbon/ester-based plasticizer.

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While celluloid is not used in many applications today, there is a long history of the plastic being used in guitar picks. In fact, the first plastic guitar picks were made from celluloid in 1922. Luigi D'Andrea bought a heart-shaped die to punch hearts to be used for decorations from sheets of celluloid. His son noticed that it resembled mandolin picks, and Luigi seized the opportunity to sell the punched hearts to a New York music store. The picks quickly caught on as the celluloid material closely resembled mandolin picks made from a tortoise's shell. The benefit of celluloid comes from the fact that it is a tried and true material for guitar picks. It offers good strength, durability, tone, and aesthetics as well as the fact that it is a material that has been used in guitar picks for almost 100 years.

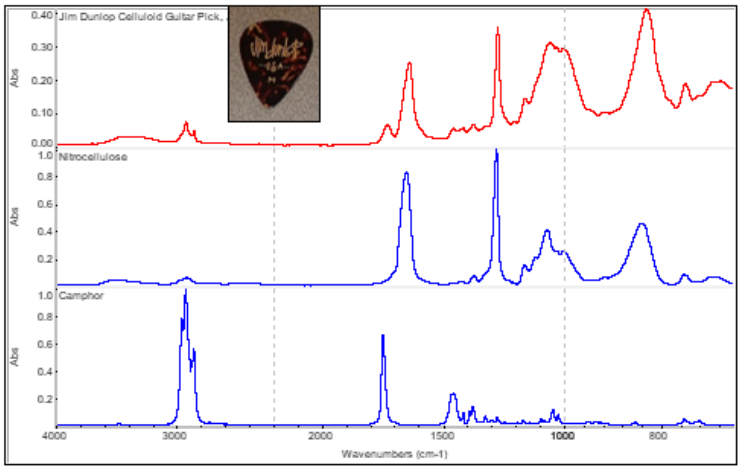

Figure 4 – Guitar pick 1 was characteristic of celluloid plastic.

Guitar Pick 2 produced an FTIR spectrum with evident hydrocarbon and amide functionalities that were characteristic of a polyamide resin (**Figure 5**). It is important to note that the type of polyamide (6, 6/6, 12, etc.) is very important for the performance characteristics and is not distinguished with this test method. Polyamide is a good choice for this material due to its high stiffness, toughness, good fatigue resistance, and compatability to a broad range of everyday chemicals.

There are a few possible downsides to polyamide including the glass transition, which is just above room temperature. This could lead to a larger variation in the guitar pick's stiffness. Additionally, the coefficient of friction for polyamide is only moderate, which could provide some grabbing on the strings during use. However, this material is a good choice for the requirements of the guitar pick.

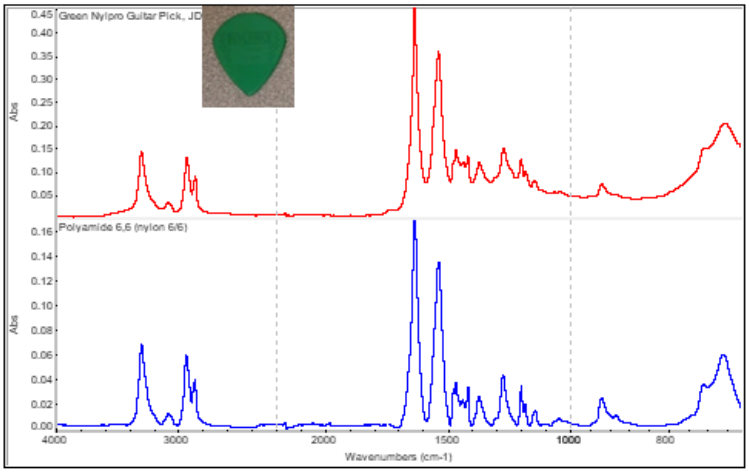

Figure 5 – The FTIR spectrum for guitar pick 2 was characteristic of polyamide.

Guitar Pick 3 produced an FTIR spectrum with a strong carbon-oxygen functionality (**Figure 6)**. The FTIR spectrum is characteristic of a polyoxymethylene (POM/polyacetal) resin with no additional formulation constituents as detectable by FTIR. Additionally, it is also pertinent to note that FTIR cannot distinguish between homo and copolymers of POM.

Benefits of polyacetal that are applicable to guitar picks are high stiffness, very good creep and fatigue properties, low coefficient of friction, and good wear properties. These properties would make a guitar pick that would provide minimal grabbing on the strings and have very long lifetimes.

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A possible downside of polyacetal would be a guitar pick that is too slippery for some players. However, this could easily be offset with surface texture in the design.

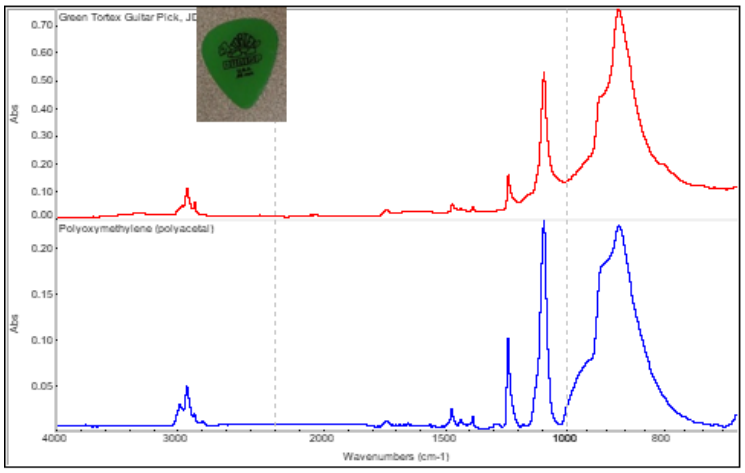


Figure 6 – Guitar pick 3 was characteristic of a polyoxymethylene (POM/polyacetal) resin.

Material selection can be a daunting task, but it can be the step that literally "makes or breaks" a product. A systematic approach to material selection can greatly improve the efficiency of this process, limit product testing requirements, reduce the risk of complications further along in the design process, and increase the probability of creating a successful product. It is true that a number of materials can satisfy the primary requirements for a guitar pick, along with many consumer products. However, putting science behind the material selection process will ensure that your guitar pick (or any other product) will by **THE** guitar pick that consumers are "reaching for."

Additional case studies can also be found at:
https://www.madisongroup.com/case-studies.html

Training

If you are interested to have The Madison Group come and speak or provide training to your team, please feel free to contact us at info@madisongroup.com.

Merry Christmas and Happy Holidays to You!

Wishing you all the joy and happiness of the Christmas and Holiday Season and throughout the coming New Year.

We appreciate and value your partnership with

The Madison Group!

Announcement—Strategic Partnership

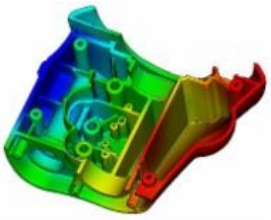
The Madison Group has exciting news that will help us better support you, our customers.

The Madison Group has entered into a strategic partnership with D3 Technologies to help support and sell the Autodesk Moldflow Suite of products. We have joined forces to provide added value in many areas beyond analysis. In addition to continuing to support your analysis needs for finding solutions to your plastic design and manufacturing applications, you can now leverage our expertise to help you find the right simulation products and proper training to help your team take on your new programs. By partnering with D3 Technologies, the software integration, and ability to improve internal workflows will be further enhanced through their extensive manufacturing software offerings.

We had the option from Autodesk to become resellers of Moldflow, but we realized that we did not want to compromise the investments in and around our services expertise. By Partnering with D3, you now have access to the only Autodesk Platinum partner solely focused on Manufacturing clients. D3 offers solutions that can help manage all aspects of your product development process, incorporating data and workflows from concept all the way through manufacturing.

With our expertise in Advanced Materials Analysis and D3's proficiency in product design, development and data technologies, our clients can approach their needs and workflows with a holistic approach and cohesive team working to grow their enterprise from every angle. Whether it is vital as enterprise-level support, or as straightforward as taking advantage of D3's virtual education platform, CAD L.I.V.E, this decision expands the ways we can help support your bigger picture goals.

Please reach out to The Madison Group at moldflow@madisongroup.com, to hear how to take your next step.



Visit Our Website

Our Full Moldflow Services can be found at:
https://www.madisongroup.com/moldflow-analysis.html

New Employee—Welcome

Welcome

Tom Hansen joins The Madison Group Team.

The Madison Group is proud to announce that Tom Hansen has joined our team as a project engineer. Tom received his B.S. in both Manufacturing Engineering and Plastics Engineering from the University of Wisconsin – Stout and his M.S. in Engineering Management from the University of Wisconsin – Platteville. Tom comes to The Madison Group with over 10 years of experience. He has worked in various areas of the plastics industry, including tooling design, in-mold labeling and silicone molding. His focus is to use CAE tools and industry experience to assist clients in optimizing and troubleshooting their plastic components and manufacturing processes. In his free time, Tom enjoys outdoor activities such as fly fishing, hunting and playing the Irish field sport, hurling.

Upcoming Educational Webinars

Thursday, December 12, 2019 - *Jeffrey A. Jansen* – Society of Plastics Engineers
Failure Associated With Injection Molding
11:00AM–NOON (EDT)

The injection molding process is one of the key characteristics that determines how a plastic part will perform in service. Manufacturers certainly attempt to avoid failure, but often unanticipated factors result in unexpected problems. The chances for a successful application can be significantly increased through preventative measures, including appropriate material selection, proper mold design, and process development. Even when appropriate actions are taken, failures can still occur. The evaluation of these failures provides an opportunity for learning. By understanding how and why a plastic component failed, steps can be taken to prevent future occurrences. Case Studies will be presented to illustrate failures associated with the deficiencies from the injection molding process. The presented Case Studies will illustrate how the failure analysis process was used to identify the failure mechanism, as well as the primary factors responsible for the failures.

Click **here** to register.

Thursday, January 9, 2020 - *Jeffrey A. Jansen* – Society of Plastics Engineers
Fourier Transform Infrared Spectroscopy in Failure and Compositional Analysis
10:00 –11:00 AM (CST)

Fourier transform infrared spectroscopy (FTIR) is a fundamental analytical technique for the analysis of organic materials. It provides critical information in the evaluation of polymeric materials, including material identification, contamination, and degradation. The webinar will present a fundamental understanding of the technique, and the following topics will be covered:

1. Theory of Infrared Spectroscopy
2. Test Results Interpretation
3. Application to Polymeric Materials
4. Material Identification
5. Contamination
6. Degradation
7. Sample Preparation
8. Supplementing FTIR With Other Techniques
9. Case Studies

Registration Information Coming Soon.

Information regarding upcoming educational opportunities can also be found at:
http://www.madisongroup.com/events.html

Upcoming Educational Webinars (cont.)

Thursday, February 13, 2020—*Jeffrey A. Jansen*—Society of Plastics Engineers
An Introduction to Plastics
10:00—11:00 AM (CST)

Plastics are the most versatile materials ever invented, and have become a universal material, used for everything from water bottles to wings on combat aircraft. Plastic materials display properties that are unique when compared to other materials and have contributed greatly to quality of our everyday life. At this moment, you are almost certain to be touching plastic. Yet, while plastics play such an important role, we do not always understand the fundamental concepts of their production, compounding, end properties, and use.

If words such as polymer, thermoplastic, creep, amorphous, and modulus are outside your normal vocabulary, this presentation is for you.

This webinar will provide people not extensively familiar with plastics an understanding of the basics.

The usefulness of plastics is attributed to the fact that they provide a wide range of properties and can be changed into and products by relatively simple and inexpensive fabrication means. In order to take full advantage of these materials, it is important to have a clear understanding of their composition and elementary properties.

Registration Information Coming Soon.

Thursday, March 12, 2020— *Jeffrey A. Jansen*—Society of Plastics Engineers
Ultraviolet (UV) Effects on Plastic Materials
10:00—11:00 AM (CST)

If you work with plastic components that include outdoor exposure, then "Ultraviolet (UV) Effects on Plastic Materials" will provide you with information that will enhance your understanding of the interaction between UV radiation-based weathering and plastic resins, and help prevent premature failure. Topics covered during this session include an introduction to UV degradation and an explanation of the failure mechanism characteristic of UV radiation/plastic interaction. Case studies associated with UV radiation exposure will be presented.

You will learn…
- The mechanism of UV degradation.
- The materials susceptible to and most affected by UV degradation.
- The effects of UV degradation on plastic materials.
- How the use of stabilizers can improve UV resistance of plastic materials.
- How testing can be used to determine whether plastic materials are susceptible to UV degradation.

Registration Information Coming Soon.

Information regarding upcoming educational opportunities can also be found at:
http://www.madisongroup.com/events.html