Research Updates

LIFE FORMS REVIEW

Summary of Responses to IAB Comments

WBC IAB Fall Meeting 2023
Lansing, Michigan
27 – 28 September, 2023

Wood-Based Composites Center

Index

Progress Ratings

Title	Great Progress	On Course	Needs Change	Off Course	Abstain
I-10-FR: Carbon Isotope Ratios: Novel View of CH2O Emissions	3	6	0	0	1
M-02-PR: In-Depth Characterization of Bondlines in CLT Made with Preservative-Treated Lumber	6	5	0	0	0
M-03-PR: Preliminary Investigation of DMDHEU-Treated Strand Board	3	6	0	0	0
M-04-FR: Wax Migration	2	7	0	0	1
N-02-MU: Long-Term Response of Wood-Based Composites in Variable Climate Conditions	2	7	0	0	1
O-02-VI: Monitoring Phenol Formaldehyde and Wax Content With VIS/NIR Smartphone Technology	1	9	0	0	0
O-05-NE: A Fundamental Study of Lignin Reaction with Formaldehyde	3	3	0	0	2
O-07-PE: Understanding the Fundamental Influence of Wood Extractives on Wood	1	8	0	0	2
O-09-SC: Near-Infrared Hyperspectral Imaging and Chemometric Techniques for Estimation of Percent Wood Failure (PWF) in Adhesive Bonds	0	1	0	0	0

Project I-10-FR: Carbon Isotope Ratios: Novel View of CH2O Emissions

Project Phase: Project Update

Project PI: Chip Frazier (VT) | Student: Mark Cashman (VT)

Progress	Count	%
Abstain	1	10%
Off Course	0	0%
Needs Change	0	0%
On Course	6	60%
Great Progress	3	30%
	10	**100%**

Questions

- Does increased surface area increase formaldehyde emissions during pressing as shown in mixed species #2?

  All the panels are formed and pressed at the same dimensions. However, the different furnishes that we are using are very different, from particle size to wood species makeup. This certainly has a possibility of affecting emissions. However, the primary focus of testing panels of various furnishes is to demonstrate the versatility and robustness of the methodology. We are not trying to draw conclusive comparisons between panels of different furnish. – Mark

- For chamber…did you compare the described chamber to the small chamber used for post-cure formaldehyde emissions from coated articles? ANSI/BIFMA M7.1-2011(R2016). I am not sure how applicable process is. It could be a point of comparison though. There is also an ASTM method that I could forward. I can't locate the number at the moment.

  We loosely ASTM D6007; this method is the most closely related standard method to the work we're trying to accomplish. This is a small-scale chamber for determining formaldehyde emission concentrations from wood products. We must take a number of liberties in order to suit our circumstances and unique requirements but ASTM D6007 is the standard method we most closely align with. – Mark

Suggestions

- May be useful to perform particulate size analyses for its effect on formaldehyde emissions.

  This is a great suggestion and definitely something we have taken into consideration before. For some of our furnish types, namely our Douglas fir which is a mix of shavings and sawdust, we don't have the best method for defining average particulate dimensions and particle size distribution. But at the end of the day, while it may play an overall role, the effect of particle size on formaldehyde emissions is not a focus of this work. – Mark

- Consider standard work spacing in tables and not evenly spaced to avoid standalone words that may be distractive to the audience.

  I'll take this into consideration for the future. – Mark

- Consider augmenting the study by adding a blank bonded with an NAF adhesive such as pMDI. This might support your conclusions on comparing natural wood formaldehyde versus formaldehyde from the adhesive.

  This is a great suggestion and definitely something we have taken into consideration before. – Mark

Comments

- Important topic for Wood based composite manufacturers. Great presentation

  Thank you! – Mark

- Good presentation. Have you considered normalizing for surface area tested as opposed to mass?

  This is a great suggestion and definitely something we'll take into consideration. – Mark

- Excellent, detailed methodology.

  Thank you! – Mark

Summary Statement

The overall reviews were good with most ratings on course and great progress. The work was presented well however, ensuring that the tables are clearer to read from the back of the room is important. Most of the comments and suggestions were based on methodology. First could you use a no added formaldehyde adhesive to get a base line of the biogenically produced formaldehyde and have this as a reference for your study.

Project M-02-PR: In-Depth Characterization of Bondlines in CLT Made with Preservative-Treated Lumber

Project Phase: Final Report

Project PI: Gerald Presley (OSU) | Student: Cody Wainscott (OSU)

Progress	Count	%
Abstain	0	0%
Off Course	0	0%
Needs Change	0	0%
On Course	5	45%
Great Progress	6	55%
	11	100%

Questions

- Did any of the impurities increase bonding potential? What thresholds were used for wood failure image analyses?

  No, we did not see any improvements. Cody can elaborate on the % wood failure determination

- Does the delamination of the post treatment test tell us anything about the effects of treatment? Could the delamination have occurred in an untreated CLT.

  No I think the delamination in post treatment tells us more about the treatment process rather than the chemical treatments themselves. Pressure treatment of composites with aqueous solutions can cause issues with delamination or at least weakening the bondline. Our untreated control panels were generally in good shape, but we cant rule out that there may have been issues with the panel layup itself. Greater replication would have been desirable to account for any unintended variability in the panel.

- Have hot-melt polyurethane adhesives been considered for future research?

  No we have not. This study was focused on mass timber cold set resins. WE could discuss some other resins for Shane's project. I believe we had current requests to look at borate or fire retardant interactions with MF or PF.

- Have you looked at any financial impacts? Sanding off such a large percentage might reduce the viability of the treatment financially.

Suggestions

- It was hard to follow the comparison slides. I would work on better presenting the data with direct comparisons between pre-layup and post-layup treatments. I want to easily look at the data and see if the bonding is better pre-layup or post-layup.

I think this could be accomplished with another set of figures reforming the data. Also, Cody needs to be more careful about saying what is different and what is not. The only piece of the data that really shows a clear difference is the % wood failure in the delamination test and the contact angle. The shear load failure and penetration data did not show differences statistically. This is a limitation of the study as our replication was not large enough to say much for certain.

- Include # of specimens.

  These are listed in the methods of the final report

- Would like more information on resins used. Mw, Mn, Pd, etc. Information on surface energy of resins would be good to have, as would information on resin rheology.

  Cody can comment further on the specific information he sought from the manufacturers. I believe he did try to get some of this information but was denied.

- Evaluate effect of a post treatment boron diffusion process, especially for hard to treat species like Douglas fir. Will this improve bond strength of boron treated laminates? Perform similar study using a different species (pick one popular in CLT manufacture - is SYP being used for CLT, treats very easily).

  The materials used in this project were produced in an industrial scale facility. The borate pressure treatment did have a period to air dry after treatment where the borates will redistribute in the wood. The manufacturers do get full or nearly full penetration by borate stain. However, Cody's data show that for the dip treatment especially, the borate is heavily concentrated in the outer layer. I'm not sure how much lower we could get the borate concentration on the surface with a diffusion process.

  Something to consider. We are using DF for Shane's project. He may not get to another species because of the effort involved, but if he makes good progress on the mode-I fracture tests, he may be able to trial another species.

- Clarify the discussion on the interaction between the resin and the treatment. Is it chemically interfering with the adhesive cure or is it a physical barrier on the wood? Verify the use of your terminology.

Comments

- Good job addressing pre vs post layup assembly. This discrepancy was mentioned last meeting. A lot of good work.

  Thank you.

- Nice work

  Thank you.

- Good presentation.

  Thank you.

- For further study: Different treatment levels for different regions of the country. Wood dust is a known carcinogen per California, does treatment make the hazards of wood dust significantly more hazardous.

  Treated wood sawdust comes with the same handling PPE recommendations as untreated sawdust for use by individuals. However, I am not sure about the manufacturing context. There may be extra considerations for worker PPE and especially disposal of the sawdust.

- Practically speaking, the focus should be on treatment of the laminates. Many CLT panels will be too large to fit in a traditional pressure treatment cylinder. Post treatment curing or drying to remove moisture from laminates will solve many other issues, such as weight for shipment, moisture level for secondary bonding, etc. Regulatory rules will require treatment of laminates or the CLT panel be performed at an EPA registered treating plant. Not at the CLT producer's facility. This area of research is very valuable to the growing CLT industry and broader wood products industry. It should be continued.

  Agree, also water based treatments can cause issues with deformations etc.

  The materials used in this study were probably drier than a typical piece of lumber because they were stored inside for some time before planing and pressing. Ultimately if treated materials are used in CLT manufacture they will have to be dried prior to layup.

Summary Statement

All responses were either great job or on course. The work was presented well but a clearer comparison of the treated and untreated would be useful. There was a great amount of work done but it would be valuable to not just present the facts but to delve deeper into the possible causes that could include resin parameters to help understand the causes. Also, discussing the practical application of these approaches. Example, if have to treat then sand before gluing what is the cost benefit and what could be the health implications at the mill.

Project M-03-PR: Preliminary Investigation of DMDHEU-Treated Strand Board

Project Phase: Final Report

Project PI: Gerald Presley & Fred Kamke (OSU) | Student: Shane Johson (OSU)

Progress	Count	%
Abstain	0	0%
Off Course	0	0%
Needs Change	0	0%
On Course	6	67%
Great Progress	3	33%
	10	**100%**

Questions

- Were press parameters the same for all treatment concentrations? Were different parameters considered?

  Yes, they were all the same. From the final report: "Strands were pressed to a final thickness of 0.5 inches (12.6 mm). Strands were placed between two platens and pressed to 0.5 inch thickness with the press heated to 200˚C for 6 minutes."

- Can curing of DMDHEU be combined in final vacuum step or just after, with introduction of heat?

  We could try it if this project continues. Surface deposits of DMDHEU may have had an impact on bonding.

- What is the baseline anti-fungal efficacy of the treatment? Did you test the soak tank water to see what it contained prior to treatment? This could also have an impact on results. Did you skew the data by having the high number of samples removed by bond failure.

  The treatment is a crosslinking agent and is not added as a biocide. Prior literature indicates that DMDHEU modification is effective at preventing fungal decay at 25% or above % weight gain. Therefore the treatments we tested were somewhat low for fungal decay, but may be useful for some increase in dimensional stability.

  We did not test the soak water. This was just tap water. Do you know what we should be looking for that can interfere? Certain metals or other contaminants?
  Ideally we would have had the same number of panels for each treatment for the IB test, but were limited in the amount of chemical we had to treat the material when the panels were made. We eventually did find a source of DMDHEU but Shane's time ran out for his undergraduate degree before we could make more replicate 10 and 20% panels.

Suggestions

- Investigation of treated strand surface quality to optimize bond strength is an area suggested for more research. A final vacuum may be needed / should be investigated. Follow this with optimization of the PF (or any) resin application rate to achieve the target bond strength. The above suggestions should be applicable to any moisture resistant treatment for wood composites. Board density impacted IB data, as well as fungal resistance due to pathway size.

  We could also do some surface characterization of the strands to try and explain some of these problems. This was not part of the original study but if we continue in this area that is something we could do.

  I agree, as stated above, that our control panels also had issues which indicates our process needs work.

- Include board making parameters. This is important to understand the bond issues seen.

  These are available in the final report

Comments

- Thickness swell sample sizes are quite small.

  If we continue this research we could increase sample size. One issue we were running into was chemical availability for this project and so we were trying to conserve chemical as much as possible. This led us to limit panel manufacture to a total of 6 16 x 16 inch panels per treatment. If we continue this project we will want to secure more DMDHEU so we can increase the sample size either as larger test panels or more replicate panels.

- Nice presentation. The project deserves further research.

  Thank you.

- Hard to believe any of the bonding data when the control panels don't hold together. I wonder if the PF resin interfered with cure of modifyer. Thybring, E. E. (2013). *The decay resistance of modified wood influenced by moisture exclusion and swelling reduction*. International Biodeterioration & Biodegradation, 82, 87-95. https://doi.org/https://doi.org/10.1016/j.ibiod.2013.02.004 Thybring paper does a great job of correlating decay resistance to moisture exclusion.

  That is a good point. If we study this further we will need to improve the process so the controls hold together. Ideally we would perform the strand modification before resin application. With this current test the fixation step was done on the press due to some issues we had with getting consistent chemical retentions when we tried to cure the strands before pressing. I think we could fix this by modifying the treating and curing process further.

- Good final summary of work to date. This work has identified some key areas for future research. Please use the final report conclusions section to advocate additional work on this or other treatments to minimize moisture effects on wood composites.

  The final report does contain some suggestions. When the publication for this effort comes out we can elaborate further based on the comments given here.

- Good presentation. Interesting topic.

  Thank you.

Summary Statement

Project M-04-FR: Wax Migration

Project Phase: Research Update

Project PI: Chip Frazier (VT) | Student: JC Stant (VT)

Progress	Count	%
Abstain	1	10%
Off Course	0	0%
Needs Change	0	0%
On Course	7	70%
Great Progress	2	20%
	10	**100%**

Questions

Suggestions

- Would like to have seen more information on GC method used. FID? MS would make sense to use as well (as you mentioned).

  I will include more GC info in future. Yes, FID used with cool on column injection. 30m DB-1ht column. -JC

- Principal Component Analysis (PCA) will reduce the number of variables you are considering by combining the most important ones showing the most variation in your data. Your number of variables will be reduced from several hundred to 1-10 with the first components being the most influential.

  Thank you! PCA sounds like it will be very useful, and I am excited to learn more about it.-JC

- Follow up with the suggestion on principle component analysis. It will be important to gather enough data to draw conclusions.

  Give strong consideration to what is considered a replicate. Multiple measurements on one press load will be different from multiple press loads.

  Replications of the extraction and analysis are an effort to probe the precision of the method. Certainly, replications of multiple panels will be necessary to determine migration and compositional change.-JC

Comments

- Good presentation. Nice job managing wood inference with GC data.

  Thank you! - JC

- Solid, fundamental work that can benefit industry... good job JC. Continued funding is encouraged.

  Thank you very much! -JC

- "good idea not to read too much into the data when you have only 1 board worth of data

  Thank you. Repetitions of extraction and GC show promise for the method, but further panel replications are certainly necessary to determine migration trends -JC

- "Good job explaining all press parameters.

  Thank you! -JC

- "Good job on the presentation. Statistical analysis will be critical on this project. "

  Thank you! -JC

- Great presentation

  Thank you! -JC

Summary Statement

JC did a good job presenting. IAB is happy with the progress.

Project N-02-MU: Long-Term Response of Wood-Based Composites in Variable Climate Conditions

Project Phase: Project Update

Project PI: Lech Muszynski, John Nairn & Mariapaola Riggio | Student: Oluwafunbi Adeleye (OSU)

Progress	Count	%
Abstain	1	10%
Off Course	0	0%
Needs Change	0	0%
On Course	7	70%
Great Progress	2	20%
	10	**100%**

Questions

- "Were test specimens provided or did you fabricate them? Were they all from the same panel or separate? Have you made attempts to reduce the noise in your results?

  All "CLT specimens" are fabricated from solid wood. The transverse specimens will be bonded "like glulam" and cut in transverse direction.

  PMM specimens are fabricated from panel offcuts of the same type available in the lab. It is unlikely that they all come from the same panel.

  All "CLT specimens" are fabricated from clear strait grained solid wood, not from CLT panels. Note that most NA manufacturers do not edge-bond their panels which would make it impossible to cut a "transverse specimen" of the kind used in the tests.

  Noise reduction filters have been used in the 2005 project. We will use them again if noise is more than just an aesthetic problem.

- How will you separate the ambient environmental fluctuations from the test data?

  The ambient environment fluctuations are an issue only when wen running the constant climate creep tests. We are troubleshooting the system and try to isolate the system from ambient fluctuations as much as possible.

  The regular tests will be conducted with cyclic humidity (like the last part of the tests presented yesterday). These are relatively insensitive to ambient climate fluctuations.

- Was temperature maintained as a constant? If so, have you given any consideration to the influence of temperature in combination with humidity on the results?

  The lab is temperature controlled. Variation of temperature happen when the building mechanics fails for couple hours. That is not a frequent occurrence, but gives us a ding on the data now and then.

Suggestions

- Good suggestions provided by audience during presentation Q&A.
- Label line colors in time-strain graphs

  Will do!

- Temp and RH have to be able to hit their setpoints in order to get useful data. Get that sorted out before running tests. We saw big improvement in reliability when moved such experiments to temperature and humidity controlled room.

  Agree. However the trouble with ambient climate is a function of failures of the mechanicals in the entire building.

Comments

- Well organized presentation

  Thank you.

Summary Statement

1. Great presentation Funbi. Your presentations are visually appealing and it is apparent that you have practiced. The update call/presentation prior to this meeting was appreciated
2. There is concern regarding the ambient temperature as this will influence your RH. Can this be addressed before moving forward or are we misunderstanding the magnitude of this effect?

Project O-02-VI: Monitoring Phenol Formaldehyde and Wax Content With VIS/NIR Smartphone Technology

Project Phase: Project Update

Project PI: Brian Via (VT) | Student: Seth Adusei (AUB)

Progress	Count	%
Abstain	0	0%
Off Course	0	0%
Needs Change	0	0%
On Course	9	90%
Great Progress	1	10%
	10	**100%**

Questions

- How large an area is sampled for each NIR measurement? Are you rotating samples/averaging to get data over a larger/more representative area? Are your resin contents solids/solids or liquid/solids?

  The samples are in batches/groups. Each batch measures 500g. Then it is loaded with 3%, 6%, 9% and 12% loadings of the PF resin. Then samples (individual flakes) are picked randomly from each batch and scanned to get NIR spectra that is representative of the whole batch. These spectra are then analyzed with Quant C software to generate chemometric models. Since it is the same blender/mixer being used, yes, the samples are rotated. It is done batch by batch. I hope this answers your question. - Seth

  The size of the NIR beam is around 12 mm. - Brian

  The resin is in liquid form. Details of the PF have parts being solid content and the rest being water. That's the constituent according to the information from the manufacturers.- Seth

Suggestions

- Good suggestions provided during Q&A on sampling technique and particle size discernment.

  Thanks to both comments. - Brian

- Would like to see initial raw spectra. Consider utilizing digital image analysis or grid method on high resolution photos to make your reference set and develop your predictive model. Consider de-noising your data and shortening your wavelength evaluation range. This will reduce the number of principal components needed for your model. Consider a 2:1 training:testing set when developing your models

  We will work on organizing that for the next meeting. These suggestions are good ideas and we will investigate to use data pretreatments and averaging through a grid method. The 2:1 ratio of model to validation data training is a good idea. - Brian

- Mojgan is right, 15 is too many PCAs. getting better handle on actual resin on flake to crossreference to NIR will help. there may be interactions between species, resin, and wax. models will get more complicated (might need to add components) as you get more variables in a single sample.

  We agree that there is too many PC's. We are working on ways to measure the adhesive content in flakes instead of batches and expect this to solve the problem.- Brian

- Would be interesting to expand beyond resin/wax coverage on flakes to more general application of coated surfaces. Including resin coated for secondary manufacture and surface coated (final surface). Would likely go beyond this current project.

  We will consider this for near future but maybe goes beyond this project.- Brian

- Really need validation samples to ensure you're not over-fitting and assess true precision. Ideally using a different source of flakes, etc. to represent full process variability. And using different PF resins/wood-species if the model is supposed to generalize across different PF resins or species?

  We will work to use validation methods to double check our prediction error and accuracy. - Brian

- Present the methods being considered to verify adhesive content on flakes for the group to provide feedback. Consider sample independence and the impact on results for the statistical analysis.

  We have been discussing with GP methods to measure the adhesive content of individual flakes so as to create sample independence. - Brian

Comments

- Nice to see MDI added to research scope. If successful, this will be a valuable tool for industry.

  Thanks to both comments. - Brian

- Interesting topic and project. Applicable across industries.

  Thanks to both comments. - Brian

- 12% resin content is very high industrially if that is solids/solids basis.

  We were trying to increase the range so as to get a better estimate of the regression line; however, we will try to ensure that accuracies and errors are appropriate for a more narrow range. - Brian

- Keep in mind that the method only scans the x-y plane and the z plane or adhesive penetration is lost.

  We learned that the different PF adhesives were probably different in molecular weight probably resulting in different levels of adhesive on the bond line. – Seth

Summary Statement

The consensus was that the project is on course with 1 great progress rating.

Multiple comments and suggestions were made on the life forms with one question. The comments focused on the project being relevant. The one question focused on sample size and the method for developing a representative area or sampling. The question also asked if resin application was based on solids/solid weight or liquid/solid weight. There was a follow up comment that a 12% application rate is very high for the industry.

Many suggestions were entered around methodology for the project. Several of these comments centered on variability, sample independence and statistical analysis. There were multiple comments on the principle component analysis and reducing the number of components considered. The committee seems to feel the investigators should carefully consider the suggestions and comments provided during questions and lifeforms to refine the study.

Please ensure you understand if you are adding resin based on liquid weight or solid weight versus the wood weight. It is important due to the resin not being 100% solids.

Project O-05-NE: A Fundamental Study of Lignin Reaction with Formaldehyde

Project Phase: Final Report

Project PI: Mojgan Nejad & Tuo Wang (MSU) | Student: Debkumar Debnath (MSU)

Progress	Count	%
Abstain	2	25%
Off Course	0	0%
Needs Change	0	0%
On Course	3	38%
Great Progress	3	38%
	8	**100%**

Questions

- Are there projects involving using LF in Plywood and OSB?

  We had a couple of projects using LF for plywood and LVL, but not on OSB yet.

- Were cure parameter variations considered?

  Not for this study, we cured all the samples at 130°C for 30 minutes. We have done extensive study on optimizing curing of LF resin in another CRIBE project.

- Did you consider mole ratio throughout to control the cannazaro reaction?

  We used a 1:2 molar ratio of lignin to formaldehyde for all the resin. This is a very good point. We will prepare another resin with a 1:1 molar ratio for this fundamental study and evaluate it with liquid and solid-state NMR.

Suggestions

Comments

- Engaging presentation with solid explanations to findings

  Many thanks!

- Good presentation. Nice detail provided.

  Thank you so much!

- Can you reduce the level of labeling to allow for the introduction of pressure. Pressure during curing will influence the final results.

Yes, we can, but that would reduce the peak intensity and signal-to-noise ratio in solid-state NMR. Great point, we can investigate this in future projects.

- Great presentation

  Thank you!

Summary Statement

IAB viewed the progress favorably. Multiple positive comments regarding presentation. A few technical questions as detailed in the life forms.

Project O-07-PE: Understanding the Fundamental Influence of Wood Extractives on Wood

Project Phase: Project Update

Project PI: Soledad Peresin (AUB), Suhasini Gururaja (AUB), John Nairn (OSU), John Simonsen (OSU), Chip Frazier (VT) | Student: Diego Cuartas (AUB)

Progress	Count	%
Abstain	2	18%
Off Course	0	0%
Needs Change	0	0%
On Course	8	73%
Great Progress	1	9%
	11	**100%**

Questions

- How were extraction parameters chosen? Is there technical justification for these parameters? Or are they defaults for the auto-extractor? What happens if the temperature/time is altered?

  The parameters were selected based on previous extractions in the accelerated solvent extractor. While the literature has reported higher temperatures, we chose to be conservative to prevent any potential damage to the samples and to avoid extracting other compounds. For instance, it has been reported that lignin derivatives increase with higher extraction temperatures. Employing shorter extraction times may yield fewer extracts, while extending the duration may reach a point of diminishing returns where additional extraction does not significantly increase yields. Hence, it is imperative to optimize the extraction process.`

- What is the purpose of comparing solid wood vs ground wood mass loss?

  Initially, we thought dichloromethane (DCM) gave complete extraction; however, the ground wood material presented 20x more extract for DCM at 75°C and 10x more extract for DCM at 85°C. For the methanol/water the ground wood extract was 6x greater than the solid wood. Showing that the most superficial extractives had been extracted. The purpose of comparing solid wood and ground wood mass loss was to have an idea of how much extractives we were removing. Traditionally, extraction is conducted on ground wood because that facilitates mass transfer and complete extraction.

- Could these extraction techniques be used for evaluation / identification of surface stains found on wood composite products in service? The source of the stains - the wood itself vs. the adhesive used or other additive.

  No; that is not the goal for this project.

- How are you planing on bonding the samples given that the extraction will alter the surface (raise grain, etc.) and yet planing would remove the extracted layer?

  As the shape and surface quality are preserved, direct bonding without machining could be a viable option. This would enable us to achieve a smooth surface prior to the extraction process and facilitate the direct bonding of the samples without the need to remove or modify the extracted layer.
  On the other hand, if the surface of the specimens is altered, it is necessary to verify the depth of the extraction, which can be accomplished through tomography. Once the depth is confirmed, the option of machining the samples by just a few millimeters can be considered, thereby preventing the exposure of any non-extracted portions.

- Mine was around alternative solvents but believe it was addressed through other questions.

  I am glad to hear that your question was addressed during the discussion.

Suggestions

- Consider a range of ground wood particulate sizes and see what is optimal for extraction.

  The use of ground wood during extraction is standard practice; we don't need to study particle size.

- Good suggestions provided during Q&A portion of presentation.

  Absolutely, the suggestions would help and improve the development of the project.

- Would be appropriate to analyze the extract for composition. GC/MS and HPLC UV/VIS may work well. Also, using a mixture of solvents as opposed to one solvents would be interesting. Application of Hansen Solubility Parameters. Solvent blends provide synergy for dissolving some materials. Use solvent blends based on output from single blend work to determine if optimal blend exists. Correlation between extraction results and bond strength planned?"

  Of course, the extractives will be characterized utilizing GCMS, LCMS, HPLC and other techniques as appropriate such as UV/Vis, FTIR among others.

  We are going to discuss the use of mixture solvents. It could be valuable.

  At this time, we have not considered the correlation between the extraction results and the planned bond strength.

- Need to present the next steps so that the group can understand the full picture of the project. Several options are available to look at the extractives impact on bonding. You could saturate ABES flakes with a specific extractive and bond those to look at the interaction of the extractive and the adhesive. You could bond samples extracted with different liquids etc. "

  Apologies if the next steps were missing. They are going to be included in the next presentations.
  Thank you for the suggestions, we will address them to evaluate the possibility of including them.

Comments

- Great visual representation of extraction results on wood appearance. Strong presentation.

Thank you for your positive feedback. It's always great to hear that!

- Very interesting topic and look forward to future research updates. The techniques discussed appear to have application beyond the focus of this research.

  Your feedback is greatly appreciated!

- Nice job so far. Interesting data and project. Broad range of applicability, especially with increased use of tropical species in NA. If not consulted, there is a book by Hon that delves into extractive chemistry and composition. May be helpful

  Thank you so much for the recommendation. I am definitely going to look at it.

- As bob suggested, different extractions will remove different fractions (polar/nonpolar) so will give you clues about what fractions are interfering in the bonding. Bonding performance after extraction with different solvents might be the most valuable first step to help you focus in on the most problematic components, becuase there will be too many components in the exttract to know what's important.

  Absolutely, that is the next step. We will be evaluating the different fractions (polar and nonpolar) to identify which one is causing the poor adhesion.

- Keep the original objective clearly in mind with future steps. Understanding the nature of the extractive (polar vs nonpolar) and the impact on the bond will be critical. What tests are planned to look at this once the extractives are quantified?

  Of course, we are going to keep the original objective in mind; otherwise, we could easily get lost amidst the possibilities that arise with each step.

  Once the extractives are quantified, both polar and nonpolar fractions of the extractives will be evaluated to identify which fraction is causing the adhesion problem. These interactions with commercial resins will be assessed using surface-sensitive techniques such as Quartz Crystal Microbalance with Dissipation Monitoring (QCMD), Multi-Parametric Surface Plasmon Resonance (SPR), contact angle and atomic force microscopy (AFM).

Summary Statement

Overall the reviews were good but the was a needs change and off course. The work was presented well. Many of the comments were based what is the exact goal of the project. The belief is that it is to determine if extractives affect the bonding and if so how to address the issue. If that is the case then a simple extraction with different solvents then followed by bonding would identify if the polar or non-polar extractives complicated bonding of if they were not the issue. If found to be the issue then can the chemistry of the resin be used to address. The approach would be to again do the above but then identify the extractives and determine if a simple pretreatment might be able to reduce their effect. This work was very well designed to develop a methodology quantify and improve the efficiency of the extractions but may not meet the needs of the project.

Project O-09-SC: Near-Infrared Hyperspectral Imaging and Chemometric Techniques for Estimation of Percent Wood Failure (PWF) in Adhesive Bonds

Project Phase: Project Update

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Progress	Count	%
Abstain	0	0%
Off Course	0	0%
Needs Change	0	0%
On Course	1	100%
Great Progress	0	0%
	1	**100%**

Questions

Suggestions

- The observed difference in nir reflectance between wood and resin is likely being discarded if the model is using 2nd derivative preprocessing. Since that difference in reflectance correlates strongly with wood failure, you might be throwing away information. Are there other pre-processing methods which would preserve this information? Seeing validation data for sample sets not used in model calibration would also be informative.

  I don't think information is being thrown away. If the difference we want to measure amongst samples is chemistry based then, in my opinion, the best way to observe those differences is to use 2nd deriv spectral data. By not using a derivative treatment, information that is retained may actually be detrimental to the model.

  To explore differences in models I used the RFP samples and 3 different spectral files. 1. 2nd deriv, 2. No math treatment (i.e. all info retained), 3. Standard Normal Variate (shift amongst spectra removed). The data is summarized in the following table. 5F (as recommended for the 2nd deriv spectra model) is used for comparative purposes.

Data set / Camera	***Number samples***	***# factors***	***R^2***	***SEC***
RFP *FX10+FX17*				
2nd derivative	*87 (#14, 24, 66 omitted)*	*5*	*0.81*	*0.087*
Untreated	*87 (#14, 24, 66 omitted)*	*5*	*0.63*	*0.124*
SNV	*87 (#14, 24, 66 omitted)*	*5*	*0.77*	*0.978*

2nd deriv spectra clearly provides the best model when 5F are used. The Untreated and SNV treated spectral models also required more factors (9 and 10 respectively), the extra factors are required to explain the noise (or perhaps it's information, it's impossible to say I think) removed by the 2nd derivative treatment. If I used the recommend number of factors for these sets then the stats were better than the 5F 2nd deriv model. Note - I am of the opinion that models with fewer number of factors are inherently better, as the more factors used the greater the chance of modeling noise.

Validation as described was not done but could easily be done.

Comments

Summary Statement