5. SUMMARY OF RESULTS AND CONCLUSIONS

Increased glyoxal content in the adhesive formulations increases the proportion of bound water within the adhesives, as well as increases the swelling resistance. Resulting from the increased glyoxal content in the adhesive formulations, an increased proportion of bound water is present which acts as a plasticizer. The plasticizing effect of the bound water lowers the glass transition temperature, reduces evaporation of water resulting from drying, and causes the adhesives to be comparably more ductile after drying.

Increased gelatin content in the adhesive formulations decreases the gelation time due to increased viscosity in the solution state, increases the strength and modulus of the adhesives, as well as the adhesive strength due to hydrogen bonding.

The results of the adhesive strength testing using bovine tissue compared to the bond strength results published in the literature may appear disappointing; however, this comparison may be synonymous with comparing apples to oranges. The tissue type between all the results was quite varied, and the wetness of the tissue was not quantified which may result in possible extreme tissue surface differences that could greatly affect the overall bond strength. However, the analysis of the adhesive strength using the glass adherends provides a measure for how much the bond strength of the adhesive bonded tissue can be improved.

Gelatin Resorcinol Dialdehyde tissue adhesives are quite flexible with respect to material properties. The flexibility of the adhesives by formulation is advantageous to the many possible uses in the human body. The adhesive strength, ductility, swelling resistance, and possibly the degradation rate of GR-DIAL adhesives can be altered depending on the formulation used. The importance of each tissue binding application should dictate the choice of GR-DIAL formulation used. When strength of the adhesive bond is of ultimate importance a formulation with high gelatin content such as formulation C should be used. If resistance to swelling is of utmost significance a formulation high in glyoxal content such as formulation G should be utilized. Where ductility and resistance to drying of the adhesive is of ultimate importance, a formulation high in glyoxal content such as formulation G should be applied. The degradation rate can be controlled by the amount of glyoxal in the formulation, but may be secondary in importance depending on the tissue binding application. If it is desirable to have a comparably slow degradation rate, a formulation high in glyoxal content such as formulation G should be utilized. If a relatively fast degradation rate is preferred, a formulation low in glyoxal content such as formulations W and C should be used.

6. FUTURE WORK

The following items should be investigated to further this study:

- An analysis of unreacted glyoxal in the adhesives in order to minimize the possible toxicity and improve the degree of cross-linking
- Histological evaluation to determine level of toxicity of adhesives as a function of formulation
- Dielectric thermal analysis to further support the existence of bound and unbound water in the adhesives
- Fatigue of the adhesives and adhesive bonded joints to characterize failure times as a result of cyclic loading
- Modification of a single chosen tissue substrate under extremely wet conditions and extremely dry conditions to measure the effects on the adhesive bond strength
- Bonding to tissue substrate using variable applied pressure during bond formation to measure the effects on adhesive bond strength
- Comprehensive study measuring the adhesive strength and fracture energy analysis of several types of tissue adhesives using a single chosen animal substrate and glass substrates
- Bonding *in vivo* using a chosen animal model

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APPENDIX: CONTACT ANGLE MEASUREMENTS OF GLASS SUBSTRATE

The surface energy of the glass slides to be used in lap shear testing was measured using a Rame'-Hart goniometer, Figure A.1. Deionized water and methylene iodide were used as the reference liquids. Using a 25μl syringe, 5μl aliquots of water and 2-3μl aliquots of methylene iodide were applied to the surface of the glass adherend for contact angle measurements. Nine to ten measurements were made for each reference liquid. The contact angle was measured by the line tangent to the sessile drop, Figure A.2. The accuracy of contact angle measurements using a goniometer is dependent upon the user, but usually is $\pm 3^0$. The harmonic mean method outlined in section 2.9.2 was utilized to calculate the surface tension of the glass adherends from the average of the contact angle measurements. The surface tension of the glass adherends was found to be 64 dyne/cm.

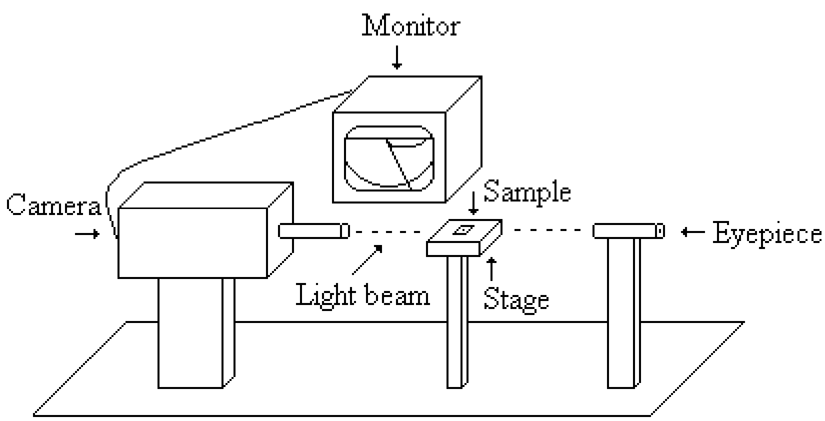

Figure A.1. Schematic Diagram of Rame'-Hart Goniometer

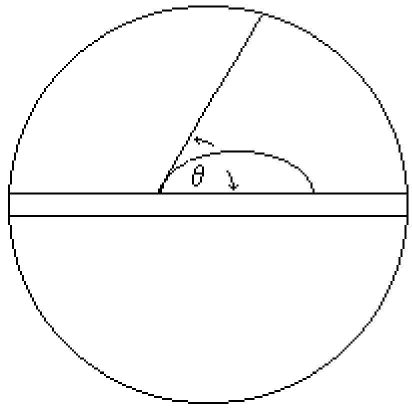

Figure A.2. Illustration of measurement of sessile drop using goniometer

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