**Salt with Differentiated Adhesion Promoters for Topical Snack Applications**
Track: Salt Production

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Consumers crave salty snack food products with various flavor and seasoning profiles. Unfortunately in many cases, there is a less than satisfying experience consuming these salty snacks due to the failure of the seasoning and/or flavorant adhering to the snack food product. A novel approach to help address the adherence issue was developed by Morton's innovation team, which improved the retention of added seasonings and/or flavorants on the "snack" substrate up to 95%. A mathematical model based on solubility parameters using the Hanson model (a tool typically used in predicting the ability of adhesion to polymers or understanding solubility and dispersion properties of materials) has been found to be useful in predicting the ability to improve adherence within salty snack applications. There are three Hanson empirically- and theoretically-derived solubility parameters that were measured – (i) a dispersion-force component (δD), (ii) a polar or dipole interaction component (δP) and (iii) a hydrogen-bonding component (δH). Each of the three parameters (i.e., dispersion, polar, and hydrogen bonding) represents a different characteristic of solvency or solvent capability. In combination, the three parameters are a good measure of the overall strength and selectivity of a solvent, and as such, may be a strong indicator towards success of adherence efficiency.

## Introduction

It has long been accepted that poor adhesion is a major factor for a salt's inability to stick to substrates, whether it be during processing, packaging, transporting, stocking or handling. During the manufacturing process, salt which does not adhere to the substrate is typically contaminated with oil and snack fragments and as result, recycling of the salt is difficult. Once a snack is packaged, loose salt is essentially wasted, as it does not serve the purpose of providing the key consumer experience of a tasty salty snack. Traditionally oils and fats have been widely used to aid in the retention of seasonings, including salt, by direct application on snack foods in high concentrations.[1] In some instances water is used and has been found to be an excellent adhesion promoter when used directly onto the food substrate. The adhesion remains intact until water is removed during the various operational conditions. If too much water is applied, it can soak into the substrate and impact the overall texture. If too little water is applied or if the humidity is too low, the water will evaporate before the salt is applied, and the salt will not adhere properly to the substrate.

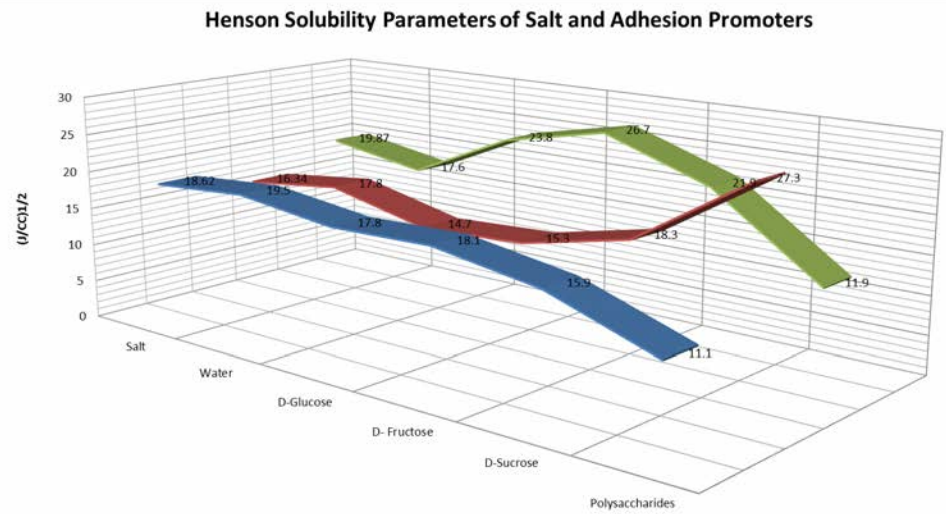
## Discussion

This study was focused on methods for adhering salt to snack substrates by applying the adhesive directly to the salt or seasoning particle versus being applied to the food substrate at very low concentrations. This improved adhesion method for the salt seasonings has the potential to minimize waste, while lowering of overall product cost and even potentially allowing for a lower sodium nutritional claim due. The process involved the addition of an adhesion promoter which was added to the salt in either liquid or solid form. Upon developing a method for applying the salt seasoned particle to the substrate, followed by agitation (representing a robust manufacturing process) the retention of the modified salt particle was quantified. The adhesives selected for the study included food grade plant proteins, hydrocolloids, polysaccharides, starches and polyols. This methodology was extended to various substrates including chips, crackers and pretzels.

To identify suitable adhesives while minimizing the number of experiments for testing adhesion promotion, a more fundamental understanding of the interactions of solubility of salt has on water and adhesives was carried out utilizing Hansen Solubility Parameters (HSP).[2] Hansen Solubility Parameters (HSP) is a useful and practical tool for providing key insights into understanding relationships between different parameters that influence surface–surface properties which ultimately may impact adhesion properties. There are three Hanson solubility parameters which form the foundation of this method, and when combined provides a good indicator for adhesion efficiency– (i) a dispersion-force component ($\delta D$), (ii) a polar or dipole interaction component ($\delta P$) and (iii) a hydrogen-bonding component ($\delta H$). Each of the three parameters (i.e., dispersion, polar, and hydrogen bonding) represents a different characteristic of solvency or solvent capability. Although HSP was used initially to determine solubility of polymers where understanding and controlling solvent-polymer interactions in stable coating systems is critical, the application towards salt interactions with various adhesion promoting polymers provides a novel approach to addressing adhesion efficiency in topical food applications. Salt solubility information and its interactions within many solvents is documented in open literature.

Figure 1 and 2 illustrates the calculated HSP values of salt, water, and various adhesion promoters relative to their respective solubility parameters.[3] One can see from their structures (Figure 2) that most of the products are poly-hydroxy compounds and the calculated hydrogen bonding and oxygen polar groups give d-glucose, d-fructose, and d-sucrose provide similar Hansen Solubility Parameters to that of water.

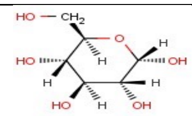
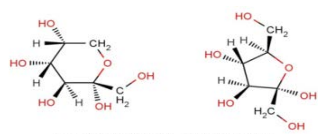
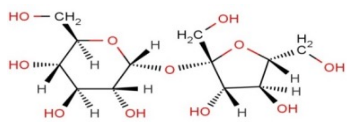
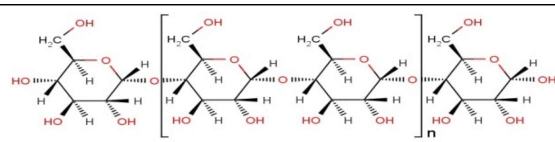
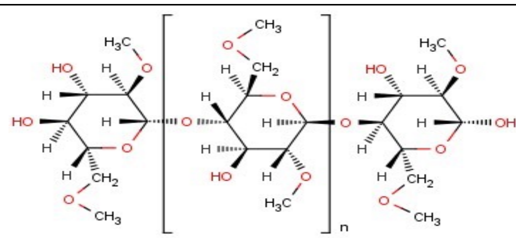
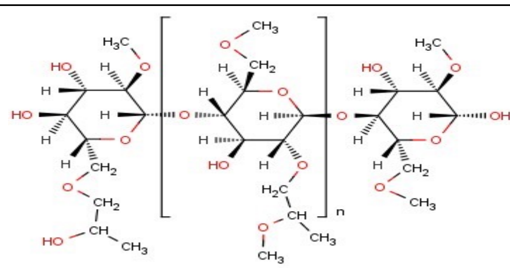
Figure 1. Hanson Solubility Parameters of Salt and Adhesion Promoters




| | Salt | Water | D-Glucose | D- Fructose | D-Sucrose | Polysaccharides |
|---|---|---|---|---|---|---|
| Hansen Dispersion Parameter: | 18.62 | 19.5 | 17.8 | 18.1 | 15.9 | 11.1 |
| Hansen Polar Parameter: | 16.34 | 17.8 | 14.7 | 15.3 | 18.3 | 27.3 |
| Hansen Hydrogen Bonding Parameter: | 19.87 | 17.6 | 23.8 | 26.7 | 21.9 | 11.9 |

Except for high molecular weight polysaccharides, hydrogen bond interactions decrease as molecular weight increases. HSP is an efficient method to quickly identify products which are likely to be useful and eliminate products which are not.

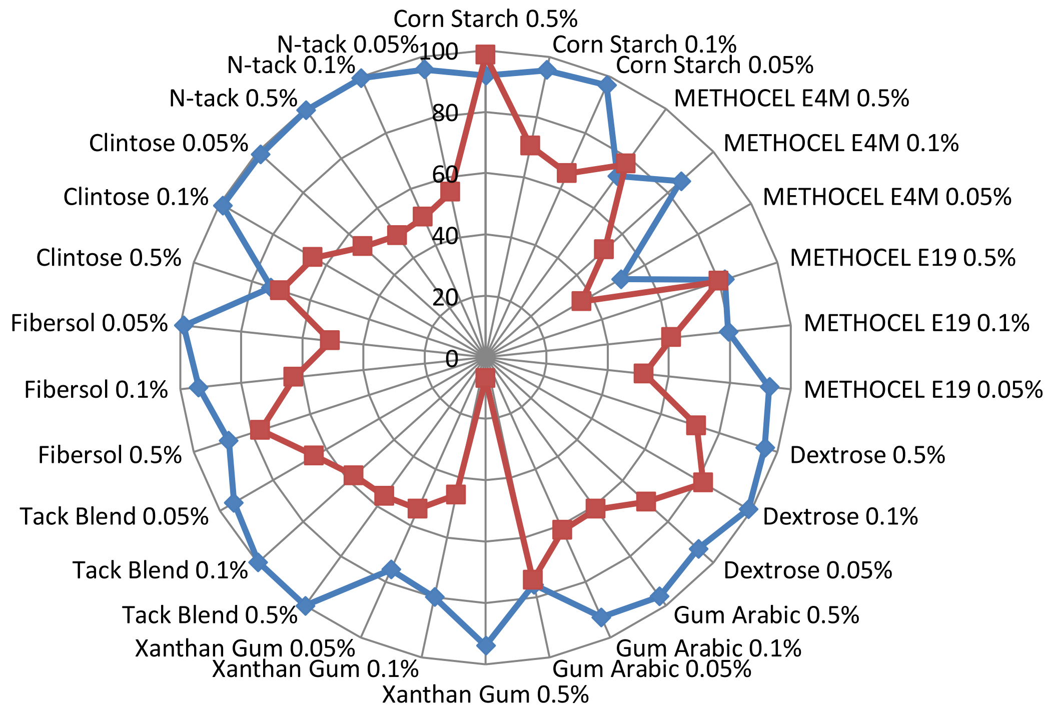
Figure 2. Hydrogen bonding and polar groups from basic sugars

| CHEMICAL STRUCTURE | SOLUBILITY PARAMETERS, (J/cc)1/2 Dispersion, Polar, Hydrogen Bonding |
|---|---|
| **Sodium Chloride** | **18.62, 16.34, 19.87** |
| **Water** | **19.5, 17.8, 17.6** |
|  α-D-Glucose | **17.8, 14.7, 23.8** |
|  The Two Major Isomers of α-D-Fructose | **18.1, 15.3, 26.7** |
|  Disaccharide | **15.9, 18.3, 21.9** |
|  Polysaccharide | **11.1, 27.3,11.9** |
|  Methylcellulose | **17.4 - 18.3, 14.6 - 16.5, 15.1 - 19.4** |
|  Hydroxypropyl Methylcellulose | **17.4 - 18.3, 14.6- 16.5 15.1 - 19.4**<br>**High Hydroxy Propyl Substitution**<br>**17.3, 9.9, 13.5** |

## Enhanced adhesion in Chip applications[4]

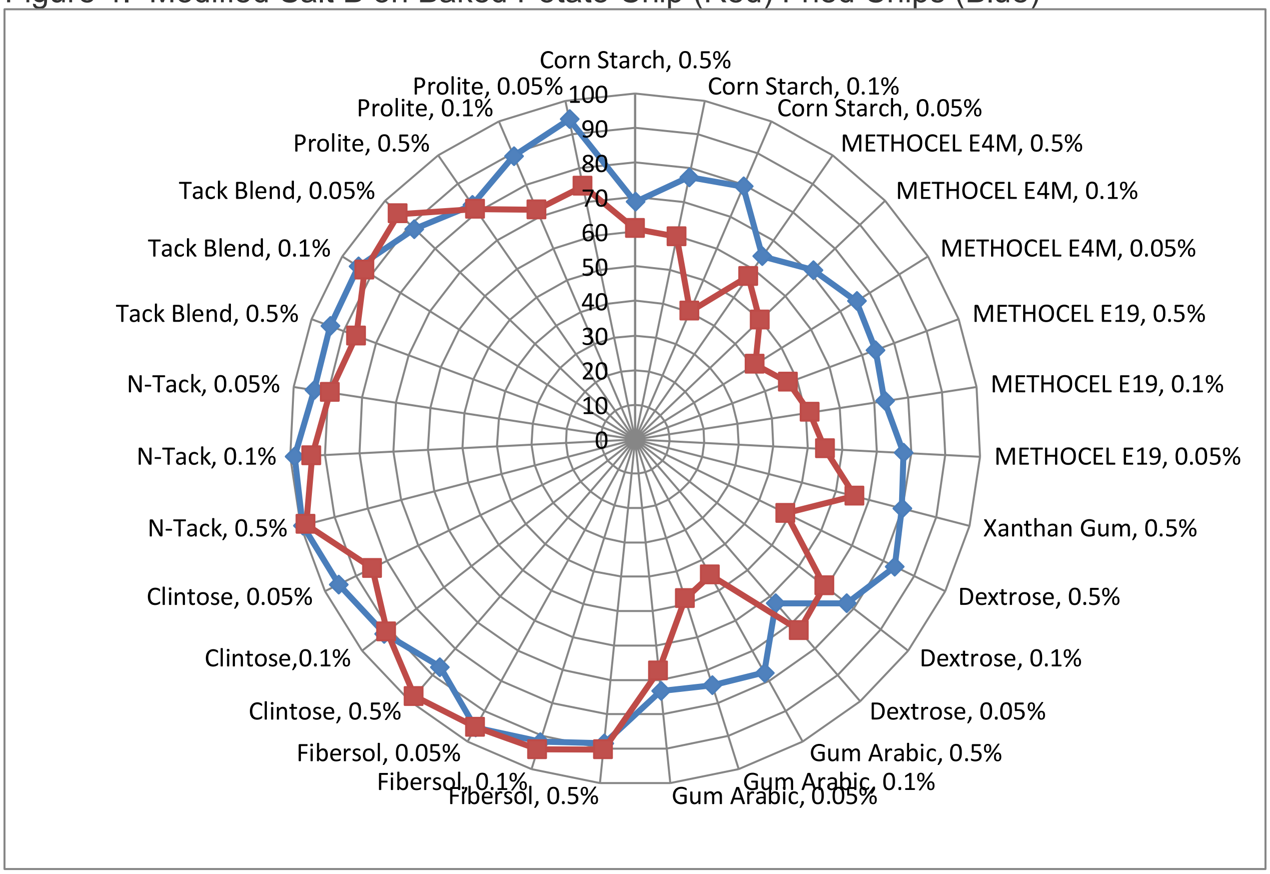
A predefined spray consisting of adhesion promoters and solvent is applied to salt particles, such that the final concentration of the promoter contained within the salt or seasoning particle is between 0.05 and 0.5% by weight. The modified salt particle A is then applied to the chips (both baked and fried chips). The substrate further undergoes a serious of unit operations to mimic those within a manufacturing environment and evaluated for retained adhesion of the modified salt A or seasoning particle. Adhesion efficiency varied across multiple promoters from 0 to almost 100% retention, with the choice of promoter, application dependent. Interestingly, we found that in several examples the retention efficiency was inversely proportional to the final concentration of the promoter on salt or seasoning particle. This finding may infer there is an optimal concentration at the adhesive boundary layer between the salt particle and the substrate, maximizing adhesion efficiency. Significant differences were also observed between baked and fried chips suggesting that promoters must be tailored per application.

Figure 3. Modified Salt A with Baked Chips (Red) and Fried Chips (Blue)



The adhesion study was further extended to understand the influence of modified salts of varying particle sizes (Figure 4.). Particle size of Salt B was chosen to be moderately smaller than Salt A. Although in general the results confirmed the expected increase by altering particle size, the impact of modifying Salt B with adhesion promoters was significantly improved over the non-modified version. In addition, it was found that the influence of the adhesion promoter was generally structure dependent with efficiencies of methylcellulose based promoters significantly different from starch and polysaccharide based promoters. Finally, within this data set it was observed that differences were more pronounced between the baked and fried chip application (larger particle size) versus the results shown in Figure 4., where efficiency differences between applications were somewhat compressed but still enhanced.

Figure 4. Modified Salt B on Baked Potato Chip (Red) Fried Chips (Blue)

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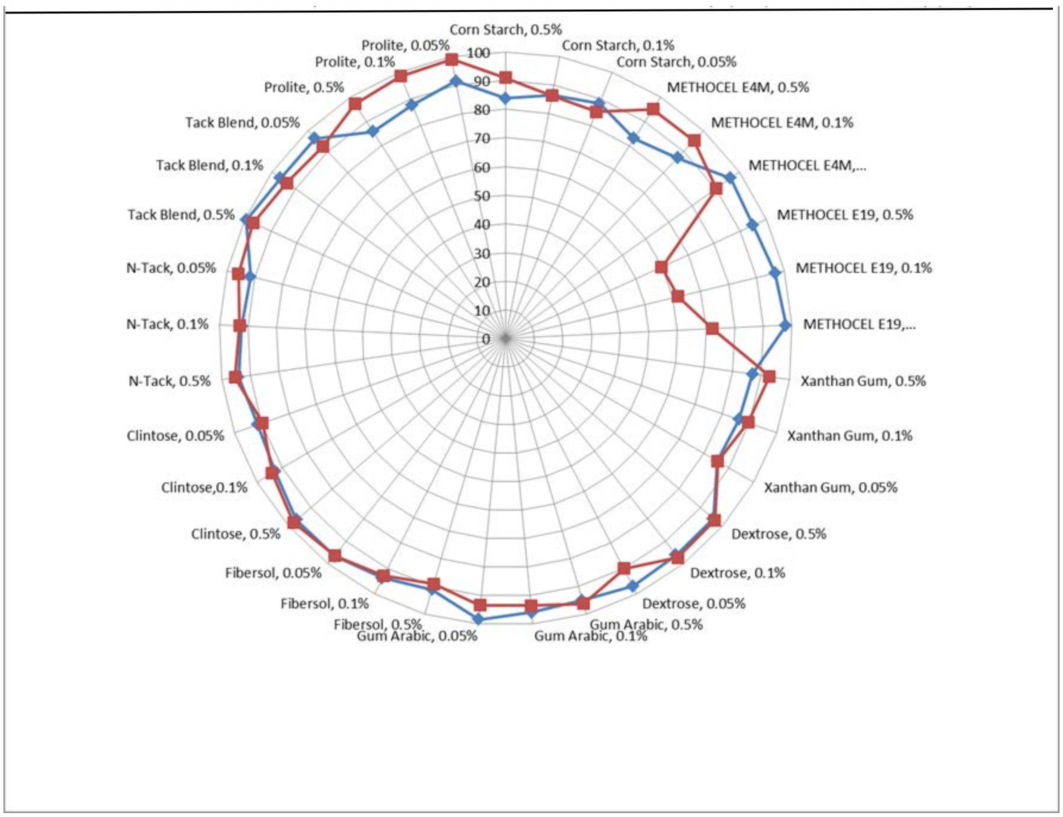
A consumer trend that has continued its popularity within the snack industry is that of sodium reduced solutions. We were interested in determining if a blend of modified salts to reduce the sodium amount would show similar behaviors to that of the modified salts by themselves. A 1:1 blend of Potassium Chloride (KCl) with Salt B with various adhesion promoters were again tested against adhesion efficiency on baked and fried chips (Figure 5.). Both applications resulted in an increased improvement of adhesion efficiency across multiple modified salts over Modified Salt B (Figure 4.) providing an outlet to deliver a novel reduced sodium topical application.

Figure 5. 1:1 Modified Salt B and KCl on Baked Potato Chip (Red) Fried Chips (Blue)



## Summary

In has been demonstrated that modified salts with various adhesion polymers can have a significant impact on the overall adhesion efficiency. In particular it has been shown that these modified salts may have significant influence on type of application, salt particle size and even the ability to provide synergistic impact on mixed salts resulting in lower sodium solutions. These adhesion polymers may be used to replace oil and sugar to adhere powders and small particles by first modifying salt and seasoning particles at very low concentration (0.05 to 0.5 wt.%) versus applying these enhancers directly to the substrate, resulting in a more efficient manufacturing process. The selection of these adhesion polymers was supported by calculating HSP values of salt, water, and various adhesion promoters, relative to their respective solubility parameters. The learnings from this output has been shown to be a reasonable predictive application tool towards salt interactions with various adhesion promoting polymers.

## References

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