GLYBOND®

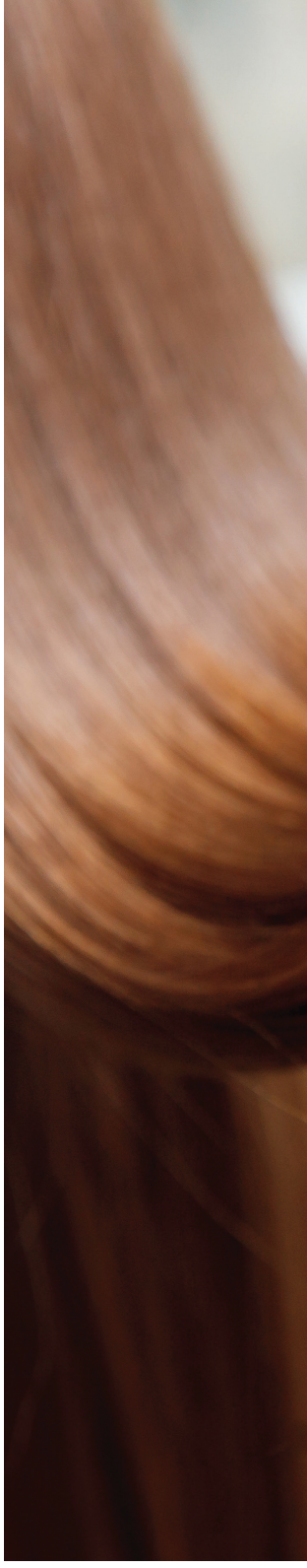
The Science of a Beautiful Bond

How Patent-Pending Polymatrix Bond-Building Technology Improves Hair Keratin Quality

CROSSCHEM

Introduction

Keratin is a natural, durable, and multifunctional protein found widely within the human body [1]. This versatility is the key to keratin's success, with a complex structure of component amino acids and the α-keratin coiled-coils giving keratin resilience, flexibility, and durability. Due to its unique adaptability, healthy keratin leads to better-looking, more robust hair. The disruption of keratin bonding, however, can lead to damaged hair strands and brittleness, and thus proper understanding of the various bond types that make up human hair keratin is crucial. In this study, the formation and cross-linking structures of amino acids will be analyzed to describe the limitations of communal and external hydrogen bonds within the intermediate filament (IF) of the hair strand. Subsequently, analysis of the bonding interactions within the polypeptide chains that make up human hair will reveal the ways in which **CrossChem's new polymatrix solution to bond-building and repair addresses** these limitations to improve the strength and health of human hair keratin.



Key Areas of Study

- The formation and cross-linking structures of amino acids
- Limitations of communal and external bonds within the intermediate filament (IF)
- GlyBond®'s polymatrix solution to bond-building and repair

The Science of a Beautiful Bond

Amino Acids and the Keratin Molecule

The smallest building block of human hair is an amino acid. Amino acids are organic molecules mainly composed of nitrogen, carbon, hydrogen, and oxygen [3]. These “building blocks of proteins” make up many molecules beyond keratin and are critical to the body’s natural processes [3]. As the name suggests, an amino acid is a molecule consisting of a carboxylic acid on one end, a carbon with a variable side chain in the middle and an amine group on the other end. The side chain on each amino acid is what differentiates them and gives each one a unique property. Twenty different amino acids are used by the human body to build various proteins and perform biological functions. Within keratin, amino acids serve as the basis for the peptide building blocks that form the larger α-helix coiled-coil. While much has been said about amino acids and their importance in human health, these molecules play an integral role in the bonding capabilities and reactive structure of keratin in particular.

Keratin is one of a number of molecules known as fibrous proteins. Including keratin as well as structures such as collagen and elastin, these molecules “contain polypeptides organized approximately in parallel along a single axis,

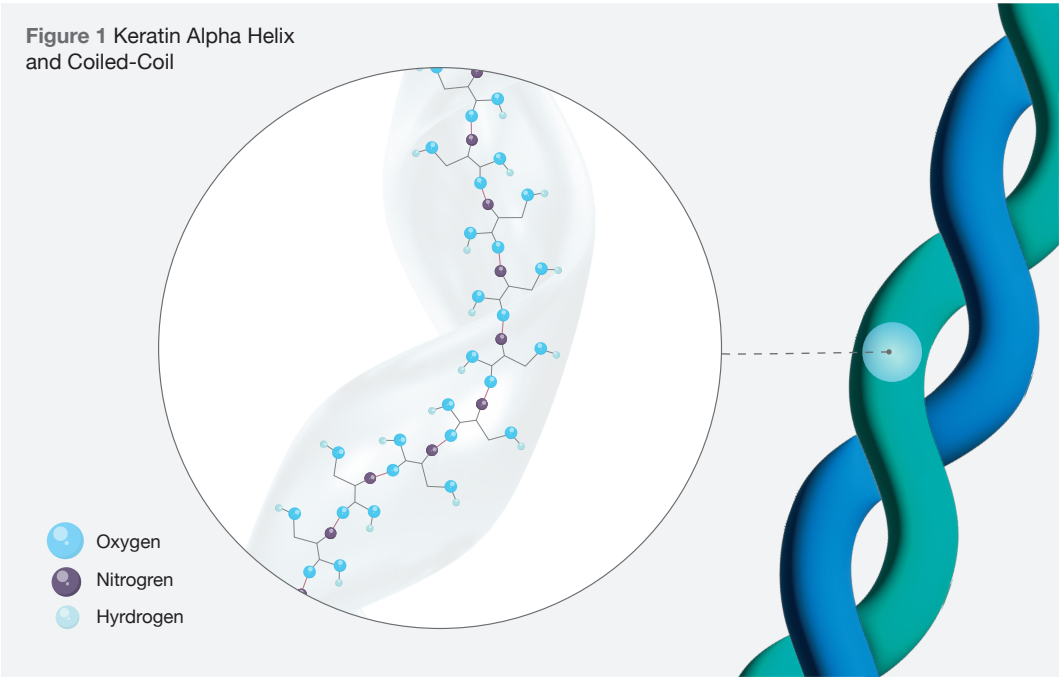


Figure 1 Keratin Alpha Helix and Coiled-Coil

producing long fibers or large sheets" [4]. A polypeptide is a long, unbranched chain composed of peptides, short sequences of amino acids linked by peptide bonds. Fibrous proteins are typically mechanically strong and usually are insoluble in water [4]. The long and narrow structure of fibrous proteins makes them less sensitive to changes in pH, temperature, and physical force [5].

While 18 amino acids are found in keratin, the predominant amino acids are: cystine (17.5%), serine (11.7%), glutamic acid (11.1%), threonine (6.9%), glycine (6.5%) and arginine (5.6%) [6]. These amino acids are strung together in polypeptide chains and through several types of chemical bonds, bind to nearby amino acids to create an α-helix. Human hair keratin exists in a fibrous form known as α-keratin, characterized by these long, chain-like structures of peptide 'building blocks' that link together into 'polypeptides' to form longer keratin molecule backbones [7]. In a hair strand, two of these α-keratin polypeptide chains twist together to form an α-helix coiled-coil, a structure known for its ability to "support[] a wide range of biological functions… form mechanically rigid structures… transduce conformational changes and facilitate the transport of other molecules" [8]. All α-helices are created through the double-bonded oxygen on the carboxylic acid being attracted to and bonding with the hydrogen on a nearby amine. This hydrogen bond formation is what twists the α-helix around to create its widely known helical shape. This coiled-coil structure enables α-keratin to work

as a natural polymer, forming greater lengths and adopting greater internal compactness [9]. The α-helix structure also gives keratin greater resistance to harmful environmental reactions while remaining internally strong through intramolecular peptide interactions that bond the α-helix chains to each other [2].

When an α-helix has been created, it can be made either basic or acidic (also called Type I or Type II), which is determined by either acidic or basic side chains [10]. In *A Helix Propensity Scale Based on Experimental Studies of Peptides and Proteins,* Scholz and Pace further describe how "some amino acids occur more frequently in α-helices than others; this tendency is known as helix propensity. Here we derive a helix propensity scale for solvent-exposed residues in the middle positions of α-helices" [11]. After the initial creation of an α-helix, a separate opposite type is connected to create a coiled coil with a gap of about 4 angstroms [12, 13]. It is therefore the positioning of the various specific amino acids within keratin that impart the α-helix behavior, which stems from the chemical behaviors of the side chains in the component amino acids.

The key to these amino acids' versatility is the chemistries of their side chains, the portions of the amino acid residue branching out from the larger hydrocarbon backbone.Within the structure of human hair keratin, amino acids form into polypeptide chains as 'residues'. A residue is what remains of each amino acid when "two or more amino acids combine to form a peptide [and] the elements of water are removed" [14]. In this way, amino acid peptides can bond to each other and to other α-helix chains to form the stable structure of α-keratin.

While the structure of keratin is stable and regular, different types of keratin (skin, nails, hair) display different concentrations of amino acid residues [15]. Each amino acid has a unique residue that allows for certain functional abilities or bonding capabilities. Because of this, hairs "contain both cationic and anionic groups," making them amphoteric molecules (able to react as both an acid and a base) and allowing a variety of internal and external bonds to be formed [16].

The Hair Strand and the Intermediate Filament

The two α-helices pair to create the α-keratin coiled-coils through three types of bonds: disulfide bonds, salt bridges and communal hydrogen bonds [13]. The strongest of these three bonds are the disulfide bonds. These are created through the linkage of two cysteine amino acids, with a length of about 4.5 angstroms, on separate α-helices [12]. These bonds are very strong with a dissociation energy of 60 Kcal/mol. In hair keratin, the primary function of cysteine residues is the formation of disulfide bonds, where Dowling et al. note that in α-keratin, constituent proteins are highly cross-linked by disulfide bonds [21]. The authors note in *The Structure, Functions, and Mechanical Properties of Keratin* that "Keratin has a large amount of cysteine residues, which have a thiol group (-SH), producing a strong, covalent disulfide bond that cross links the polypeptide chains together" [2]. Cruz et al. expands the scale of this bonding in *Peptide—protein interactions within human hair keratins*, stating that the "propensity of the formation of disulfide bonds

between cysteines among inter and intra-chains of the keratin" means cysteine disulfides bond both the interiors of α-helices and bond α-helices to one another in order to form the larger hair strand [22].

The next strongest bonds are salt bridge bonds which consist of the interaction of the acidic (positively charged ion) side chains of one α-helix with the basic (negatively charged ion) side of another α-helix [13]. For example, an acidic arginine has an extra hydrogen on its nitrogen, which causes the molecule to be less stable, and therefore causes the molecule to want to be stabilized. Glutamic acid's chemical stability, the ease by which it is metabolically produced and removed, and its negative charge, will help it stabilize the arginine residue [23]. The arginine will want the basic glutamate, which has a deprotonated oxygen, to come and bind to the extra hydrogen. In this instance, both the oxygen on the glutamate and the nitrogen on the arginine are sharing the hydrogen, creating a salt bridge. Although this bond is rather strong, it can easily be broken by a swing in pH or the introduction of water [13].

Lastly are the hydrogen bonds, a versatile third type of bond created in the formation of the α-helix coiled-coil. The flexibility of hydrogen bonds is central to α-helices' ability to stretch and recover from stresses. Within keratin, two variants of hydrogen bonds are found: internal hydrogen bonds and communal hydrogen bonds. As previously discussed, internal hydrogen bonds proximally form between nearby amino acids as part of the formation of a single α-helix. This hydrogen bond length (between the oxygen and nitrogen) is found to

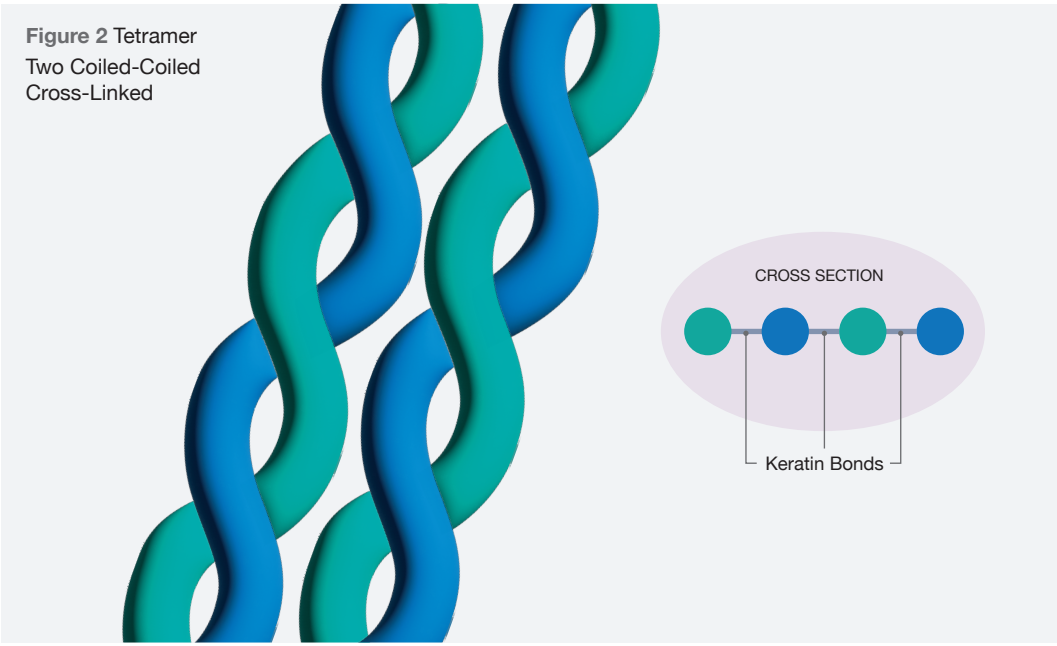


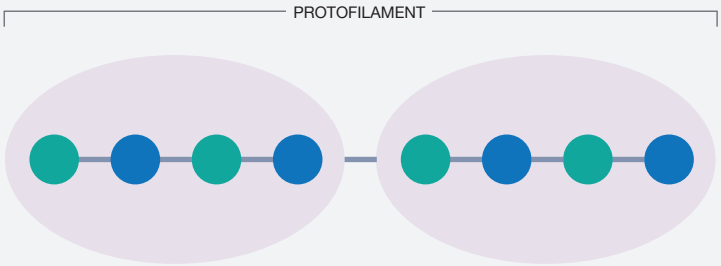
Figure 2 Tetramer
Two Coiled-Coiled
Cross-Linked

be 2.8-3 angstroms, with stretching beyond 3.5 angstroms causing complete bond disassociation [24].

Communal hydrogen bonds, on the other hand, are crucial in fastening two α-helices together and building α-helices into the coiled-coil structure of hair. Communal hydrogen bonds are classified as hydrogen bonds between two corresponding α-helices that hold them together to help create the coiled-coil. As stated before, two right-handed α-helices, Type I and Type II, will be connected to form a left-handed coiled coil. With a disassociation energy of 5.57 Kcal/mol, communal hydrogen bonds play a large role in this connection as they allow elasticity and movement of the hair without lasting chemical damage [24]. This is due to the variability of side chains on the amino acid back bone. Though each amino acid has a unique molar mass, on average the molar mass of an amino acid is approximately 110 g/mol [25]. These rough estimates inform the typical size of various amino acid sub-components within larger keratin strands. They also help clarify the geometric restrictions that might prevent residues on different α-helices from forming a crosslink. While overall communal hydrogen bonds are weak, they successfully stabilize hair through sheer numbers as each side chain that comes off an amino acid backbone has the ability to form a potential communal hydrogen bond.

By building a “continuous ‘spine’ of hydrophobicity,” amino acid residues build the opposite side of the α-helix to be “rich in amino acids with either charged side chains or uncharged polar side chains” [27]. These conditions allow

Figure 3 Protofilament
Two Tetramers Cross-Linked



the three types of bonds described above to weave two α-helices together to create a coiled coil **FIGURE 2**, which is then connected to another coiled coil to create a tetramer **FIGURE 3** [28]. Once a tetramer has been formed, it is attached to another tetramer from head to tail to create a protofilament **FIGURE 4**. Eight of these protofilaments are used to create a structure called an intermediate filament (IF or KIF (Keratin-intermediate filament)) where one protofilament is surrounded by seven others. When combined this structure has a diameter of 75-90 angstroms **FIGURE 5** [28].

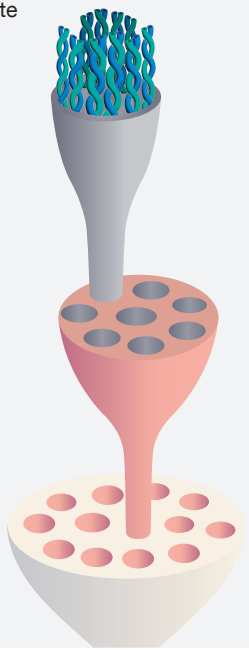
Surrounding these KIF's are Keratin-associated proteins (KAP's) which form a dense matrix containing a high percentage of sulfur that crosslinks KIF's, ensuring stability [29]. This KIF-KAP structure form macrofibrils which have indistinct features and vary heavily between each fiber, hair and person. Generally, these macrofibrils have three main types of structures in human hair which are based on the three types of macrostructures that make up the cortex in hair: orthocortex, mesocortex, and paracortex [30]. The orthocortex is a less uniform and more spaced-out part of the cortex with intermacrofibrillar material (IMM) between each macrofibril. This creates a more porous hair structure that can easily be inundated with water or other liquid materials [30, 31]. Oppositely, the paracortex is a very regular structure with many of the macrofibrils binding adjacently with little to no IMM. This high density of macrofibrils gives it a high resistance to chemical and physical attacks due to the high sulfur content of the KAP matrix creating a stronger barrier between the IF and the external environment [32]. The mesocortex is simply the middle of these two structures and is both semi-strong and semi-porous.

Although these three structures are the most predominant in hair fibers, there is variability between each cortex with many different structures still being categorized to this day [30]. For entire hair structures, the changes in these cortexes mean differences in the way the hair looks when subject to different environments [33]. For example, a hair strand with more orthocortex than paracortex may appear straight when dry however, when subject to water the different cortexes will contract different volumes of water leading to crimped hair.

Hair Strand Bonding

As previously discussed, hydrogen bonds throughout the hair structure – the α-helix, coiled-coil, and intermediate filaments – are what give each hair its elasticity. Other bonds in the hair such as disulfide bonds and salt bridges may stay together through certain physical and chemical changes however, once broken they have no ability to reform themselves unless treated within very limited conditions [13]. Hydrogen bonds, on the other hand, can flexibly break and reform their linkages easily. In many cases, the dynamic nature of hydrogen bonds come into play when the polypeptide structure of hair comes under stress, whether chemical or mechanical. The extent to which hydrogen bonds can "flex" to absorb stresses and later restore shape when tension is released is integral to hair's keratin structure [2]. The key limiting factors in hydrogen bonds formation are (1) the availability of another atom to stabilize the hydrogen; and (2) the distance between these two molecules being short enough that intramolecular forces can apply to bridge across and form a bond [34].

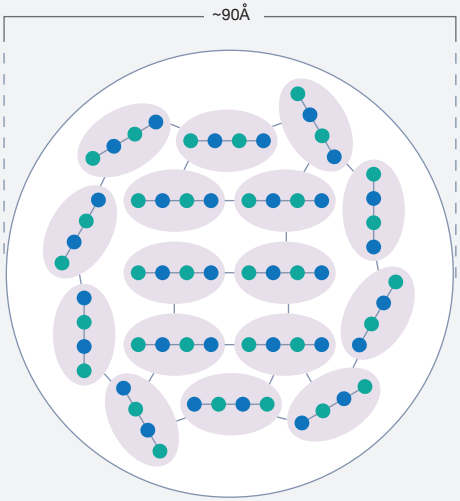
Figure 4
Intermediate Filament



Variations in these two parameters can lead to three different types of hydrogen bonds being formed: weak, moderate, and strong with the ranges for these three energies varying heavily in literature with the most liberal estimates being 0.2-40 Kcal/mol [35]. In a biological context however, strong interactions do not occur, and most moderate bonds are considered strong [36]. With this context the internal hydrogen bonds of α-helices sit around 4.2 Kcal/mol with 2.8-3 angstroms distance between the nitrogen and oxygen meaning that they sit on the threshold of weak and moderately strong hydrogen bonds [24].

Under ideal conditions, the internal structure of the hair strand allows for a system of bond formation that is both versatile and strong. The weak, moderate, and strong bond types are

Figure 5 Angstrom Length of IF
Natural or Existing
Mol Weight at
~2-5 Angstrom



the best-case scenario for each amino acid and will provide the most stability. However, the beauty of communal hydrogen bonds within hair is that, when the coiled-coil system is structured correctly, many of the amino acid residues can connect with each other. If one α-helix has an asparagine, it may want to connect to a glutamine for the strongest connection however, it has full ability to connect to a serine if that is the closest amino acid that offers the most stability. Effectively, each coiled coil is stable due to the flexibility of the communal hydrogen bonds, which provide the typical resistance needed for everyday stress without losing structural integrity. This same principle of hydrogen bond adaptability applies to external hydrogen bonds as well.

Bonding Limitations

While the crosslinked, hydrogen bond-stabilized, polypeptide structure of the α-keratin coiled-coil provides a strong and practical backbone for human hair strands, several factors can serve either to limit the strength of the α-helix or compromise the effectiveness of the internal hydrogen bonds. Molecular damage, through either mechanical forces or harmful molecular interactions, can disrupt the typical hydrogen bonding capabilities of the α-keratin structure from the coiled-coils up to the intermediate filament [12]. These disruptions can separate the strands of the α-helix, limiting the effectiveness of the internal hydrogen bonds and weakening the hair structure.

Furthermore, the matrix surrounding the intermediate filament (IF) stage is rich in cystine, which is much more rigid than the hydrogen bonds and will not easily reform once broken [12]. At scales beyond the intermediate filament, while some crosslinking is possible, the large number of combined coiled-coils present too much cystine for easy breaking and reforming of hydrogen bonds [12]. Additionally, the strongest bonding and crosslinking in the hair molecules are seen in ideal scenarios in which hair samples have not been exposed to damaging environmental factors that could degrade the effectiveness of the α-keratin coiled-coil. In *Water-Soluble Polymers in Hair Care,* the authors noted that cosmetic hair treatments often lead to a loss of strength in the hair strand due to breakage of internal bonds [38]. The authors also noted that absent any treatment, these breakages "leave the hair more susceptible to breakage and cuticle erosion from subsequent grooming" [38].

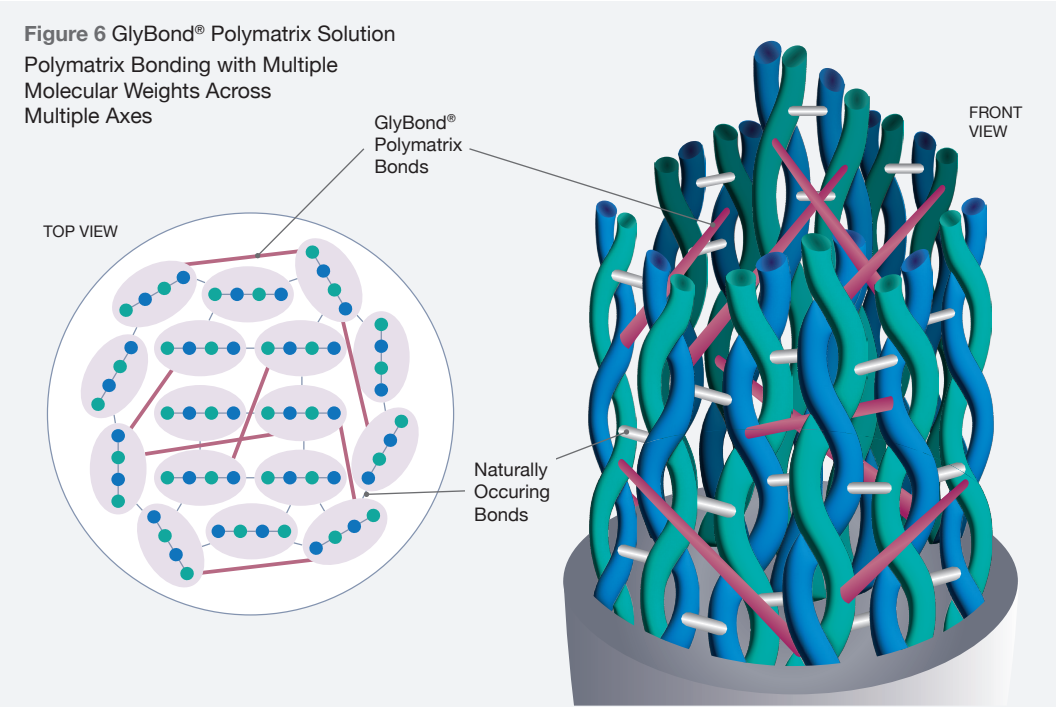
The typical communal hydrogen bond has a disassociation energy of 5.57 Kcal/mol when it is sitting in a vacuum. However, when exposed to water, the disassociation energy drops all the way down to 1.93 Kcal/mol [24] or a 65% drop in energy. This shows a dramatic drop in hydrogen bond stability when exposed to a small nucleophilic molecule, such as water. This is likely due to the polar oxygen on a water molecule easily coming into close contact with a hydrogen bond and providing a

more stable alternative. When exposed to water, the tertiary structure of α-helices is heavily disrupted and creates a much more unstable structure once the water leaves [24]. This instability after the water exits the system is linked to the reformation of these hydrogen bonds internally rather than externally to the α-helix. In hair, this exact same linkage problem will occur for communal and external hydrogen bonds as they are creating the same types of bonds in different locations. Over time, more and more of these broken hydrogen bonds will create more internally stable but less externally stable α-helices, coiled-coils, tetramers, and intermediate filaments. Although it sounds good, this creates a less stable hair system, as the amount of crosslinking between structures decreases. Because "the energetics of hydrogen bonds within proteins [are] known to undergo large changes in water" the more often water can repeatedly enter and exit the system, the less stable the overall hair strand structure will be [24].

Another way in which damage can limit the normal bonding functionality of the α-keratin coiled-coil is through mechanical disruption of α-helices in hair keratin, separating formerly-bonded helices to distances beyond the normal limits at which internal and communal hydrogen bonds remain bonded. Stretching a hydrogen bond beyond 3.5 angstroms will lead the bond to disassociate and, unless both nucleophiles are brought within reach of the hydrogen again, they will stay separated. In practice, this results in cases where damage to

hair strands causes abnormal separations between paired coiled-coils, tetramers, and intermediate filaments shifting proximally-located molecular regions away from each other and permanently breaking hydrogen bonds. In hair, this could mean that stretching to a certain limit will cause the α-helices to restructure themselves and turn into beta pleated sheets [37]. In the cases described above, an additional molecular solution would be required to both prevent polar water molecules from easily entering and exiting the system, and to bridge the gaps caused by structural damage to bonding between the polypeptide strands in the parts of the α-keratin.

Solutions to limitations in hair strand bonding can be found in the bonding capabilities of α-hydroxy acids, such as glycolic acid. The carboxyl and hydroxyl molecular ends in these molecules allow them to bond easily and effectively amongst hydrogen bonds, and their greater length allows them to simultaneously bond in locations where damage has cleaved hydrogen bonds beyond 3.5 angstroms, otherwise dissociating them. α-hydroxy acids, such as glycolic acid, further strengthen hair keratin by recreating these communal and external hydrogen bonds, providing more stability to the system. The normal molar mass of glycolic acid, 76.05 g/mol, illustrates its ability to bond within the hair strand and interact with amino acid residues (generally about 110 g/mol) while penetrating the hair strand. The beauty of the system is that even though water decreases the stability of the



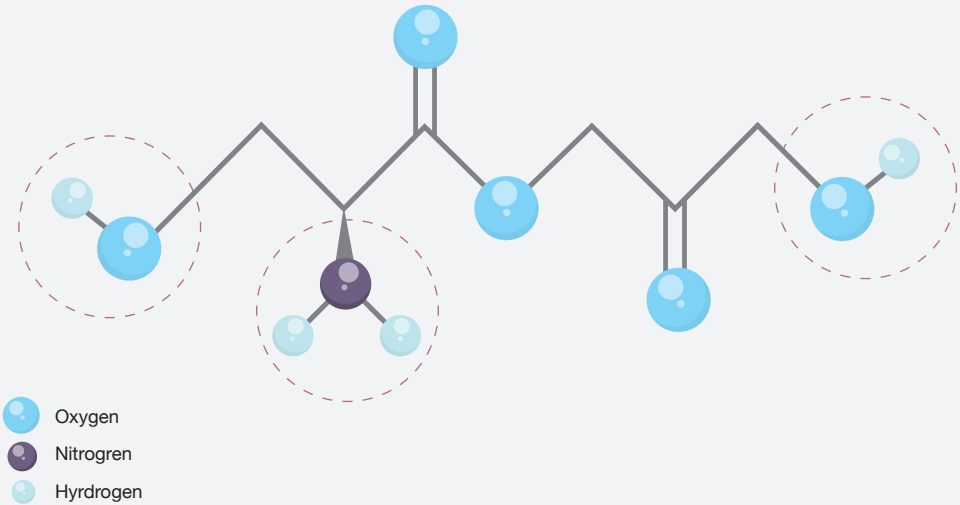
hydrogen bonds, glycolic acid takes advantage of this by creating new hydrogen bonds that stay when water evaporates. Later, when water is reintroduced introduced to the system, it has a harder time breaking through the protective framework established by glycolic acid and disrupting existing hydrogen bonds due to the length of the bonds made with glycolic acid being smaller thus, more stable. Glycolic acid's natural ability to form and reform hydrogen bonds makes it a powerhouse in stabilizing hydrogen bonds and preserving the integrity of α-helices and the coiled-coil structure in hair.

The GlyBond® Solution

While research has demonstrated glycolic acid's effectiveness in strengthening hair keratin and the structure of human hair keratin has been extensively discussed, the hydro-gen-bonds within human hair keratin offers the key to even greater benefits to hair health.

While α-hydroxy acids, and glycolic acid in particular, offer a solid foundation in the repair and reinforcement of hair hydrogen bonds, the chemical abilities possessed by glycolic acid can be adapted to further augment human hair strength. Even with the inclusion of glycolic

Figure 7 GlyBond® Polymatrix Solution:
Patent-Pending New Molecule
CAS Registration Number: 2911626-49-6
CA Index Name: Serine, Carboxyethyl Ester



acid in the hair strand, there is a limit in the extent to which one type of molecule can repair varying types of breakage or stabilize various regions of the hair strand. With a set molecular weight and size, glycolic acid may not be able to cover all situations in which a potentially-disrupted hair hydrogen bond might be reformed.

CrossChem's new patent-pending **GlyBond®** molecule **FIGURE 6** is the perfect tool to respond to these limitations and improve the effectiveness of hydrogen bond-based hair repair and strengthening treatments. **GlyBond®** relies on the tried and true hydrogen bonding capabilities of glycolic acid and couples it with the amino acid serine to create a next-level hair strengthening solution. Serine's polar uncharged side chains and hydroxy end allow them to form simple hydrogen bonds readily and effectively, creating an improved hair strengthening molecule. **GlyBond®**'s serine-glycolic acid compound incorporates the best features of both the glycolic acid and serine molecules. The result is a structure that can bond effectively and easily with the amino acid residues found within α-helix coiled-coils, possesses hydroxy ends to enhance hydrogen bonding abilities at multiple binding sites, and is composed of non-toxic, naturally-occurring sub-components that will integrate non-disruptively with human hair under a wide range of circumstances.

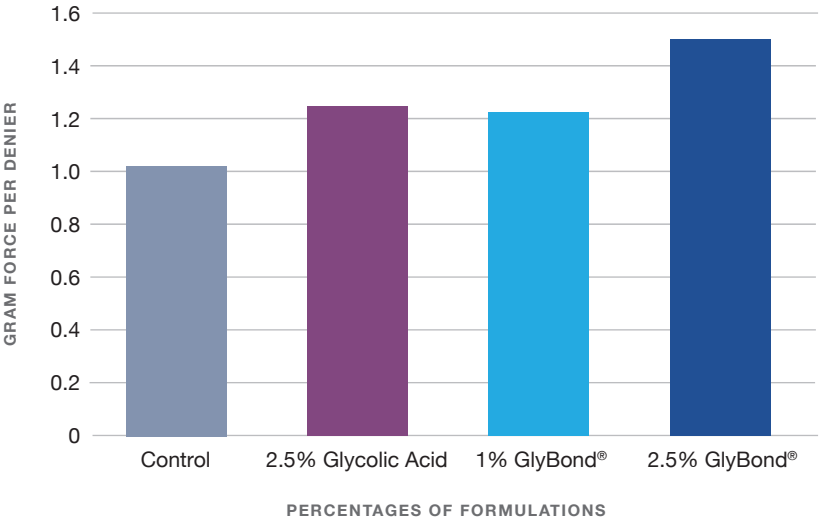
The molecular abilities of **GlyBond®** as compared to baseline glycolic acid help "bridge" greater distances, allowing **GlyBond®** to reach

disrupted hydrogen ends at a wider range of separation as compared to glycolic acid. As previously discussed, hydrogen bonds lengths are typically in the range of 2.8-3 angstroms, with bond separation beyond 3.5 angstroms causing complete disassociation [24]. With a length of approximately 4.13 angstroms, glycolic acid can step in to bridge these gaps when and where they occur [39]. However, when hydrogen bonds are disrupted beyond a 4.13 angstrom length, or when building diagonal crosslinks within the hair, a molecule with a greater range is needed. **GlyBond®** solves this problem by using the coupled serine-glycolic acid structure to deliver a molecule that behaves like glycolic acid while offering even more improvement to hair health and strength. In essence, **GlyBond®** can traverse distances beyond regular glycolic acid.

Working in tandem with the molecular solution described above is the polymatrix approach. In the polymatrix system, the foundational characteristics of **GlyBond®** are the building blocks for a multifunctional system designed to treat disruptions to the hair strand at the α-helix, tetramer, and intermediate filament levels **FIGURE 7**. In the polymatrix system, the ability of **GlyBond®** to be formulated in iterations of varying molecular weights and lengths allows α-hydroxy-like bonding abilities to be extrapolated into a dynamic system that can be tailored to reach many instances of hydrogen bond breakage. The inclusion of various, **GlyBond®**-derived molecules with similar bonding capabilities over different lengths allows the polymatrix system to bond throughout the entirety of the hair structure, from the smallest coiled-coil to the largest intermediate

Table A Tensile Strength Comparison of Various Formulations of GlyBond® and Glycolic Acid

CrossChem
in-house data

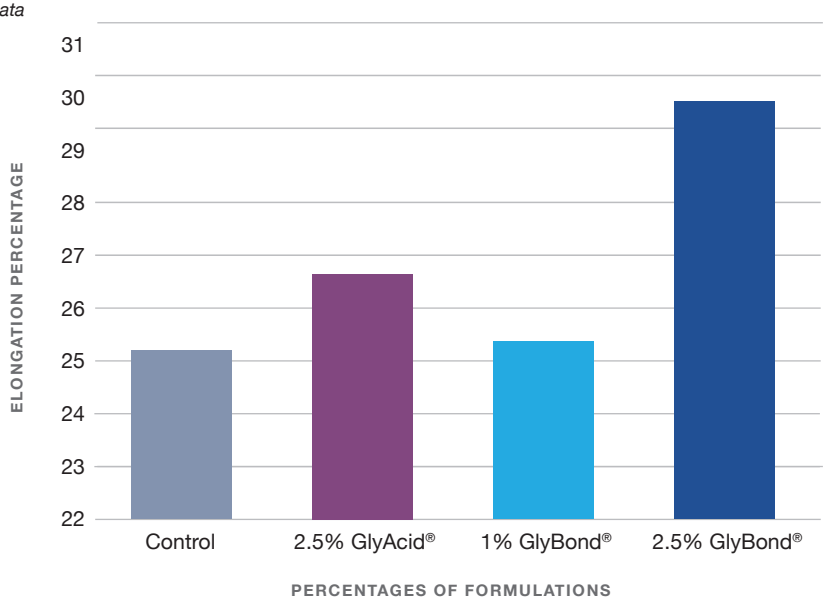


filament. In this context, **GlyBond®** molecules of multiple and varying molecular weights can also be teamed with glycolic acid to create a truly comprehensive hair care formulation, able to reach and restore hydrogen bonds wherever they may be found. Each molecule in the system is designed to fill a specific niche to create new hydrogen crosslinks. The result of this polymatrix system is a multi-molecular weight system working together to create new communal and external hydrogen bonds that span many different sized gaps.

By repairing tough hydrogen-bond breakages and taking advantage of its multi-molecular weight structure, **GlyBond®** can improve both physical and mechanical properties of hair. Testing of the **GlyBond®** molecule demonstrates its effectiveness in meeting the demands for an effective hair-strengthening treatment. In one test **TABLE A**, the tensile strength of **GlyBond®**-treated hair samples were measured against both untreated control hair strands and hair strands treated with glycolic acid. In these tests, untreated hair strands had a tensile strength of around 1.035 Gram Force per Denier (g/den). Comparatively, samples treated with 2.5% glycolic acid solution displayed a tensile strength of approximately 1.219 g/den, and samples treated with 1% and 2.5% solutions of the **GlyBond®** product had tensile strengths of 1.210 g/den and 1.490 g/den, respectively [40]. This data demonstrates clearly demonstrates the improved tensile strength offered by

Table B Elongation Percentage Comparison of Various Formulations of GlyBond® and GlyAcid®

CrossChem in-house data



GlyBond® as compared to the control, while at the same time exhibiting the superior strengthening abilities of the **GlyBond®** molecule as compared to regular glycolic acid.

In another test **TABLE B**, hair treated with a 2.5% **GlyBond®** solution was found to have an elongation percentage of 29.9% [40]. In comparison, samples treated with 2.5% glycolic acid had an elongation percentage of 26.71%, and untreated control samples, an elongation percentage of 25.23% [40]. This test further corroborates the observations from the tensile strength test, validating **GlyBond®**'s extreme effectiveness in improving the physical properties of hair and further enhancing the types of benefits to hair seen in simple glycolic acid treatments. Altogether, these tests confirm the effectiveness of **GlyBond®**'s serine-glycolic acid compound as a holistic hair care ingredient.

While prior research has described the chemical and mechanical effects of glycolic acid of human hair keratin, the amino acid composition and α-Helical structure of the hair strand mean that a bond repair solution comprised of a single-length molecule is limited, and a **GlyBond®**-based polymatrix solution offers one of the clearest answers to the problem of hydrogen bond breakage in hair.

Conclusion

While the limitations of communal and external hydrogen bonds within the intermediate filament (IF) of the hair strand environmental stresses can damage hair keratin beyond the normal ability of hydrogen bonds to reform, an ability to bond flexibly and incorporate multiple molecular weights and lengths offers a successful avenue to the development of a comprehensive bonding solution. This approach can be seen in the new **GlyBond®** molecule and polymatrix bonding, a versatile and adaptable system shown to improve hair strength and health. **GlyBond®**'s effective serine-glycolic acid structure, polymatrix approach to integrate multi-molecular weights, and ability to spur hydrogen-bond formation in hair keratin, all help demonstrate the ways in which **GlyBond®** stands as a new, revolutionary hair care solution. **GlyBond®**'s molecular system can span different-sized gaps, targeting adjacent, tangential, and more distant hydrogen bonding sites to reinforce and rebuild communal hydrogen bonds. Through this multi-leveled approach, **GlyBond®** uses the science of a beautiful bond to repair and restore stability to the structure of human hair keratin.

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