MILBON

News Release

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Milbon Develops Repair Technology to Improve Hair Strength during Hair Coloring
-Gallic Acid Enables Stable Protein Cross-Linking Even Under Strongly Oxidizing Conditions-

Milbon Co., Ltd. (head office: Chuo-ku, Tokyo, President and CEO: Hidenori Sakashita), a manufacturer of salon-exclusive haircare products and cosmetics, has developed a repair technology that utilizes gallic acid[*2], a type of plant-derived phenolic compound[*1], to form protein cross-linking[*3] under strongly oxidizing conditions, such as those encountered during hair coloring. We have also confirmed that this approach improves hair strength. The results of this research were presented at the following conference.

[Presentation]

Academic conference: 35th IFSCC Congress
Title of presentation: Innovative protein cross-linking technology using natural polyphenols to restore hair structure: Recovery of hair strength using quinone cross-linking in hair dye treatments containing hydrogen peroxide
Date of presentation: September 15-18, 2025

[Research Background]

Proteins make up approximately 85% of hair and are damaged by hair coloring and other treatments. As damage progresses, proteins are more easily leached out during hair washing, weakening the hair, causing hair breakage and split ends.
To address such challenges, Milbon has focused on post-coloring care and developed repair technology that mitigates the leakage of damaged proteins. We have reported that this technology utilizes plant-derived phenolic compounds to form protein cross-linking, thereby retaining the proteins inside the hair and slowing the progression of damage (Figure 1, gray). (Milbon Develops Technology Enabling Shape Memory at the Molecular Level of the Beautiful Condition of Hair Immediately after Coloring [News Release, March 14, 2025])

In the current research, we hypothesized that enabling cross-linking not only after hair coloring (Figure 1, gray) but also during the coloring process (Figure 1, green) would allow "preventive" repair to occur simultaneously with damage, in addition to "post-damage" repair of hair proteins, thereby leading to healthier hair. However, conventional hair coloring agents have strong oxidizing power to alter hair color, which may create a harsh environment for cross-linking reactions. For this reason, it was predicted that cross-linking reactions would be difficult to advance correctly when performed simultaneously with hair coloring. Therefore, in this research, we worked to establish a technology that enables simultaneous hair repair during hair coloring by forming stable protein cross-linking even under strongly oxidizing environments such as those encountered during hair coloring.

	Area of efforts to date	Area of efforts in this research
	After hair coloring	During hair coloring
Phenomenon	Protein damaged by hair coloring is leached out during daily hair washing	Hair protein is damaged by hair coloring
Measures	"Post-damage" repair by formation of protein cross-linking in daily care after coloring	"Preventive" repair by forming protein cross-linking

Figure 1. Conceptual diagram of expanded use of cross-linking technology to repair protein damage due to hair coloring

[Study Findings]

Confirmed the conditions under which gallic acid forms protein cross-linking under strongly oxidizing environments

We confirmed the ability of gallic acid, one of the plant phenolic compounds, to form protein cross-linking. By performing SDS-PAGE[*4] and hair tensile tests, we confirmed that while gallic acid has the ability to induce protein cross-linking, this ability is reduced under strongly oxidizing environments such as those found in hair coloring agents.

It is well known that many radical species[*5] exist in strong oxidizing environments such as those present in hair coloring. Radical species are highly reactive and easily react with surrounding materials, which can cause a variety of side effects. For that reason, we hypothesized that the presence of excess radical species might exert an adverse effect on the protein cross-linking reaction. Therefore, we added a chelating agent[*6] known to suppress the action of excess radical species and confirmed by SDS-PAGE that protein cross-linking by gallic acid was enhanced. We also confirmed that it improves hair strength (Figure 2).

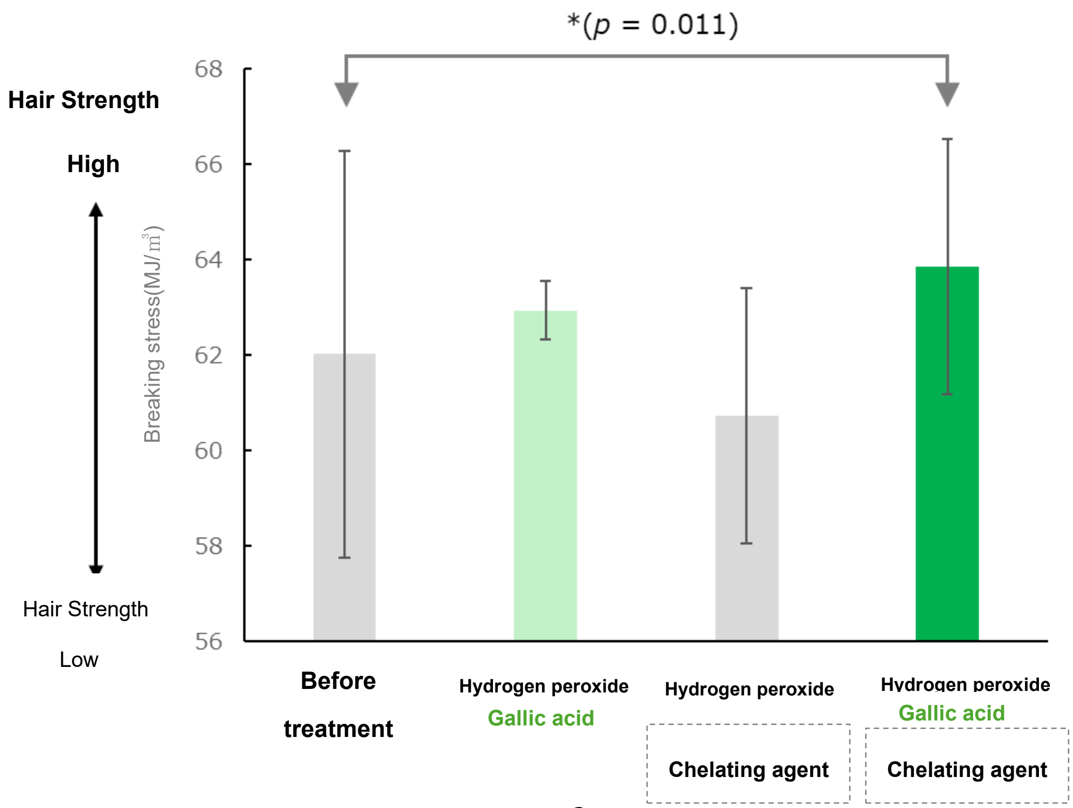


Figure 2. Results of hair tensile tests

Gallic acid shows limited ability to improve hair strength under strongly oxidizing conditions in the presence of hydrogen peroxide (second from the left), but the presence of chelating agents significantly enhanced hair strength (far right)

[Future Vision]

We will leverage this research to the development of hair coloring agents with advanced repair functions that enhance hair strength by inducing cross-linking of proteins, while also achieving beautiful hair color.

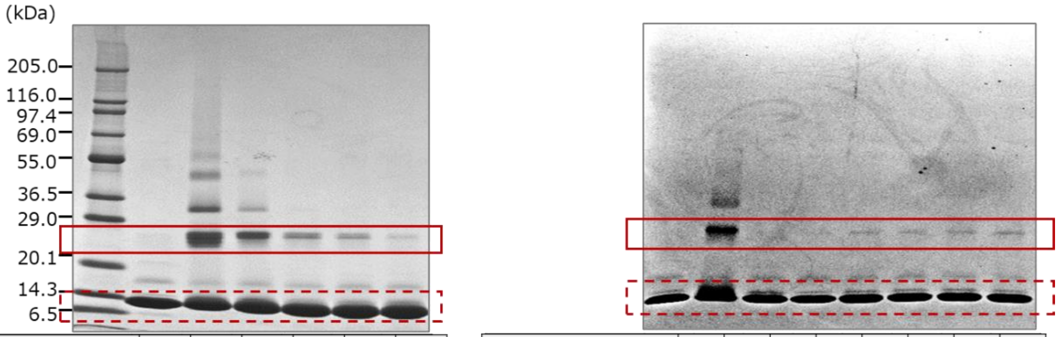
《Supplementary Information》 Method for Confirming Protein Cross-linking Formation

When other substances bind to a protein, the molecular mass increases. SDS-PAGE was used to confirm the changes in molecular mass. We confirmed that molecular mass increased when the model protein was subjected to the action of gallic acid, but the effect became smaller under oxidizing conditions with hydrogen peroxide (Figure 3a).

We also conducted the same test under oxidative conditions with hydrogen peroxide in the presence of a chelating agent under oxidizing conditions. As a result, we confirmed that the protein exhibited an increase in molecular mass when the chelating agent was used in conjunction (Figure 3b).

These results indicate that under non-oxidizing conditions, protein cross-linking occurs via gallic acid, whereas under strongly oxidizing conditions, the presence of a chelating agent enhances similar protein cross-linking (Figure 4).

(a) (b)



(a)

Lane	1	2	3	4	5	6
Model proteins	○	○	○	○	○	○
Gallic acid	-	○	○	○	○	○
Hydrogen peroxide(%)	-	-	0.5	1	2	3

(b)

Lane	1	2	3	4	5	6	7	8
Model proteins	○	○	○	○	○	○	○	○
Gallic acid	-	○	○	○	○	○	○	○
Hydrogen peroxide(%)	-	-	○	○	○	○	○	○
Chelating agent	-	-	-	A	B	C	D	E

Figure 3. SDS-PAGE patterns of products obtained with model proteins, gallic acid, hydrogen peroxide, and chelating agents

(a) The band around 14 kDa was shifted by approximately 2-fold to around 28 kDa by gallic acid (Lane 2) Depending on hydrogen peroxide concentration, the shift to around 28 kDa was attenuated (Lanes 3-6)

(b) The band shift caused by gallic acid (Lane 2) was inhibited by hydrogen peroxide (Lane 3), but the band shifted when chelating agents were used in conjunction (Lanes 4-8)

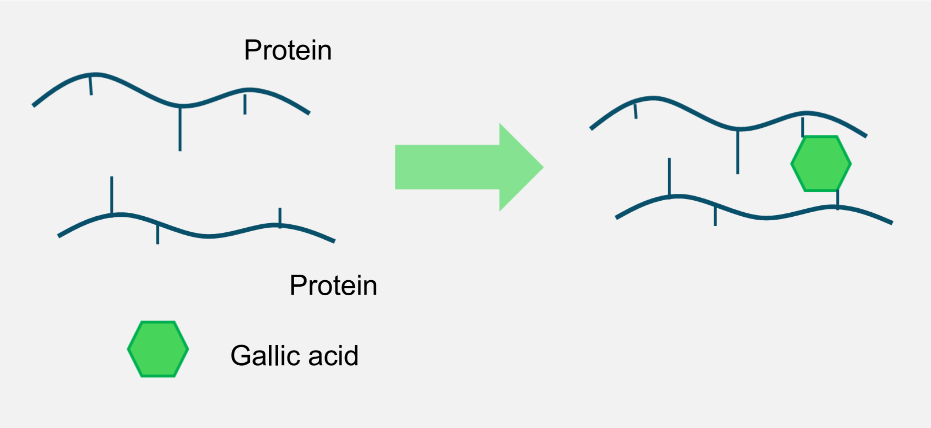


Figure 4. Example image of protein cross-linking via gallic acid

≪**Terminology**≫

*1 Phenolic compounds

A general term for substances that have a hydroxyl group (-OH) attached to an aromatic ring. They are found in many plants and play an important role in biological defense.

*2 Gallic acid

A type of phenolic compound produced from plants and used as a food additive and antioxidant.

*3 Cross-linking

Formation of a chemical bond between two molecules or within one molecule to form a bridge.

*4 SDS-PAGE (sodium dodecyl sulfate-polyacrylamide gel electrophoresis)

A technique for separating proteins in a sample based on their molecular size (molecular weight).

*5 Radical species

An atom, molecule or ion that is highly reactive and has an isolated unpaired electron. Also called "free radicals," active oxygen is a typical example.

*6 Chelating agent

A compound that forms a stable complex with metal ions to suppress the reactivity of that metal. Although different from radical scavengers, they also indirectly suppress radical generation involving metal ions.

■ **For Inquiries relating to this news release:**

milbon Co.,Ltd. Public Relations, Kyobashi Edogrand, 2-2-1 Kyobashi, Chuo-ku, Tokyo, Japan

Phone: +81-3-3517-3915 Fax: +81-3-3273-3211