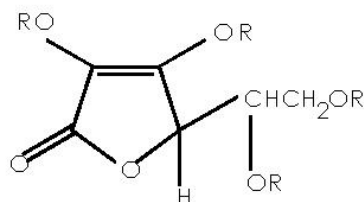


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## Oil-Soluble Vitamin C Derivative **PERFECT-C (PC)**



INCI Name : Ascorbyl Tetraisopalmitate

Vitamin C has many functions as a cosmetic ingredient, including skin lightening, promoting collagen synthesis and inhibiting lipid peroxidation. ascorbyl tetraisopalmitate is stable at high temperatures and has good solubility in oils. PC exhibits excellent percutaneous absorption and effectively converts into free vitamin C in the skin to perform various physiological functions. PC is approved as a quasi-drug active in Japan (at 3%). It is also registered in Korea as a functional ingredient for skin lightening at 2% concentration.

### Properties of PERFECT-C

- Superior percutaneous absorption
- Inhibits activity of intracellular tyrosinase and melanogenesis (whitening)
- Reduces UV-induced cell / DNA damage (UV protection / anti-stress)
- Prevents lipid peroxidation and skin aging (anti-oxidant)
- Good solubility in common cosmetic oils
- SOD-like activity (anti-oxidant)
- Collagen synthesis and collagen protection (anti-age)
- Heat- and oxidation-stable

### Physical properties of PERFECT-C

Appearance	: Colorless to pale yellow liquid
Specific gravity (d <sup>20/20</sup> )	: 0.930 - 0.943
Refractive Index (n <sup>25D</sup> )	: 1.459 - 1.465



Vitamin C



Whitening



Collagen  
Synthesis



Anti-oxidant



DNA  
Protection



UV  
Protection



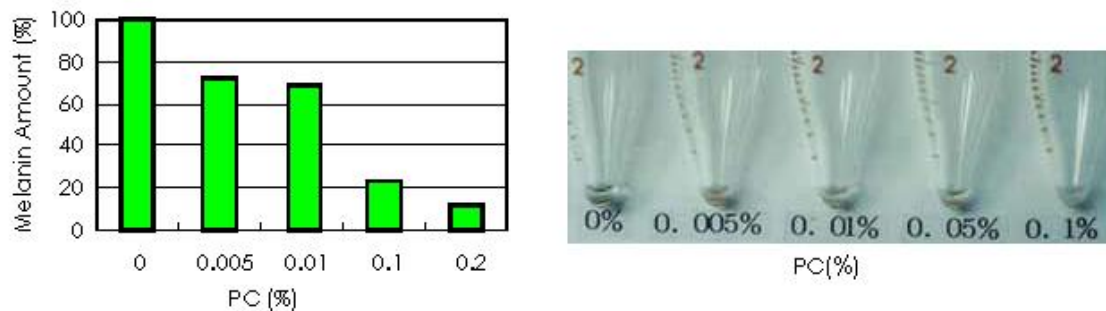
Stable

## Skin Lightening / Anti-Pigmentation



### Inhibition of Melanogenesis

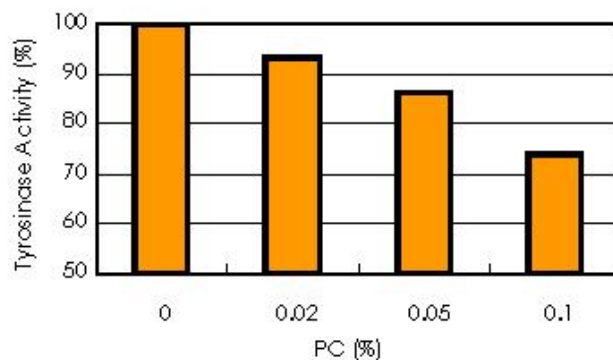
Various concentrations of PC were added to cultured human melanoma cells (HM-3-KO). After 4 days of cultivation, the amount of melanin produced was measured by observation of the color tone of each cell pellet. As shown below, PC effectively inhibited melanogenesis in human melanoma cells. Results were dose-dependent.



Melanogenesis Inhibition of PC (in Human Cells)

### Inhibition of Intracellular Tyrosinase Activity

PC was added into mouse melanoma cells (B16-4A5) at various concentrations. After a 72-hour cultivation, the cells were dissolved and extracted. L-Dopa was then added to the extract. After 60 minutes at 37°C, the amount of dopachrome formed by the activity of tyrosinase was evaluated by measuring its absorbance at 540 nm. Figure below shows that at a concentration of 0.02% and above PC inhibited the activity of intracellular tyrosinase.



Inhibitory Effect of PC on Intracellular Tyrosinase Activity

### Clinical In-Vivo Study on PERFECT-C (3%)



Number of volunteers: 30

Testing site: Inner side of volunteer's upper arm

Testing period: 3 weeks

Procedure: For the first step of the test, minimal erythema dose (MED) of each volunteer is measured using solar simulator. Briefly, 6 doses of UV ray are irradiated to the inner side of right upper arm. After 24 hours from irradiation, MED is judged. For the second step, 1.5 MED of UV ray is irradiated on the inner side of left upper arm of each volunteer in order to make pigmentation. Sample application is started just after irradiation. Sample is applied twice a day during test period. Sample application sites are randomly changed in every volunteer in order to do justice.

### Result



Placebo

3% PC

### Formulations used in the evaluation

	BLANK	TEST Sample (PC 3%)
(A)		
Ceteth-20	1.0	1.0
Sorbeth-40 Tetraoleate	0.5	0.5
Glyceryl Stearate	1.0	1.0
Cetanol	5.0	5.0
Squalane	10.0	10.0
Isocetyl Myristate	6.0	6.0
Triethylhexanoin	3.0	3.0
Jjoba Oil	1.0	1.0
Dimethicone	0.2	0.2
Tocopherol	0.1	0.1
Propylparaben	0.1	0.1
(B)		
PERFECT-C	-	3.0
Distilled Water	-	-
(C)		
Xanthan Gum (2% soln.)	5.0	5.0
1,3-BG	5.0	5.0
Metylparaben	0.2	0.2
Distilled Water	61.9	58.9

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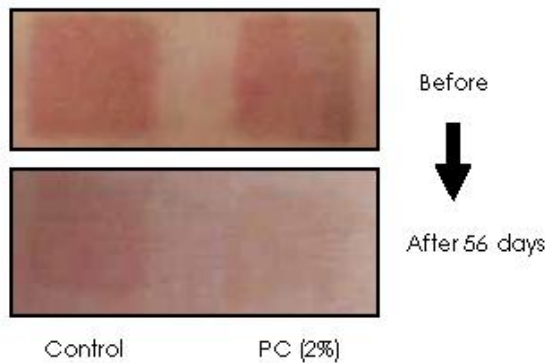
## Skin Lightening / Anti-Pigmentation



### Other Clinical In-Vivo Studies with PERFECT-C

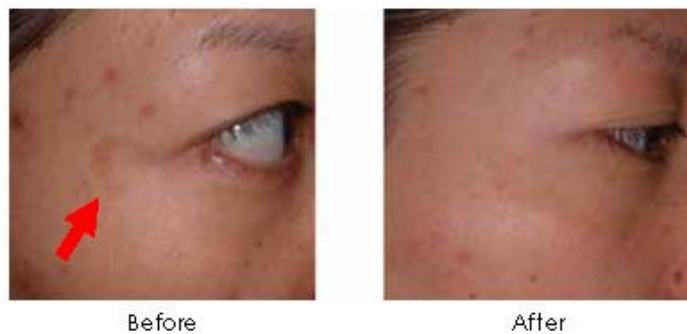
#### Reduction of UV-induced pigmentation

Test period: 56 days.  
Concentration: 2%.



#### Pigmentation reduction effect

Test period: 16 weeks.  
Concentration: 10%.  
Result: complete removal of pigmentation (age spot).

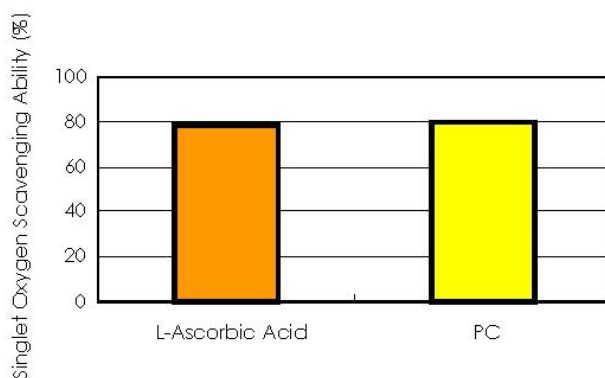


## Anti-oxidant



### Singlet Oxygen Scavenging Ability

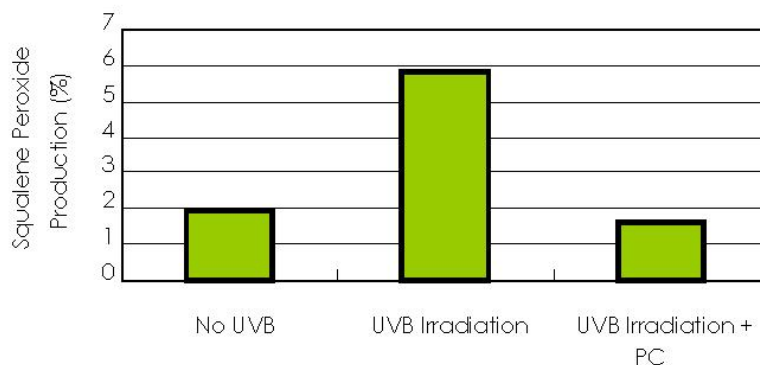
PC can scavenge singlet oxygen and prevent it from oxidizing L-Dopa to dopachrome. In order to evaluate this ability, UVB was used to irradiate mixture of Hematoporphyrin and L-Dopa with PC/ L-ascorbic acid to produce singlet oxygen and subsequently dopachrome. The amount of produced dopachrome was then determined through its absorbance. Using this measured value, the singlet oxygen scavenging ability of each PC/ L-ascorbic acid was calculated. As shown in figure below, PC and L-ascorbic acid scavenged 80% and 78% of singlet oxygen, respectively.



Singlet Oxygen Scavenging Ability of PC  
(UVB Irradiation: 4 hours, Concentration:  $2.5 \times 10^{-4}$  mol/L, Amount of dopachrome was determined through its absorbance at 475nm. )

### Inhibition of Sebum Oxidation

PC (10% in mineral oil) was applied to the inner forearms of 6 volunteers. UVB ( $2.05 \text{ J/cm}^2$ ) was used to irradiate the test site 4 hours after application. Then the production rate of squalene peroxide was measured as an indicator of sebum oxidation. As shown below, PC inhibited the production of squalene peroxide at the same level as the control without UVB irradiation.

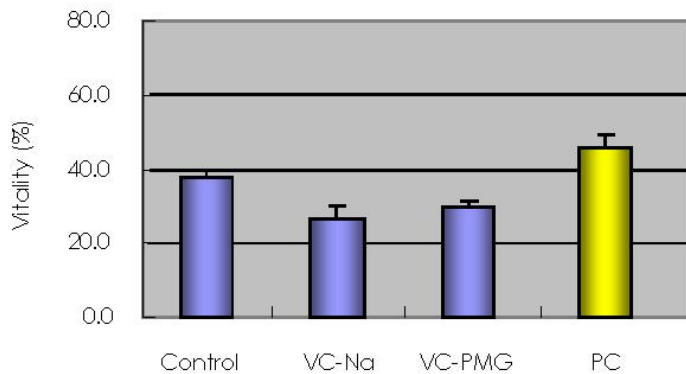


Inhibition of Sebum Oxidation



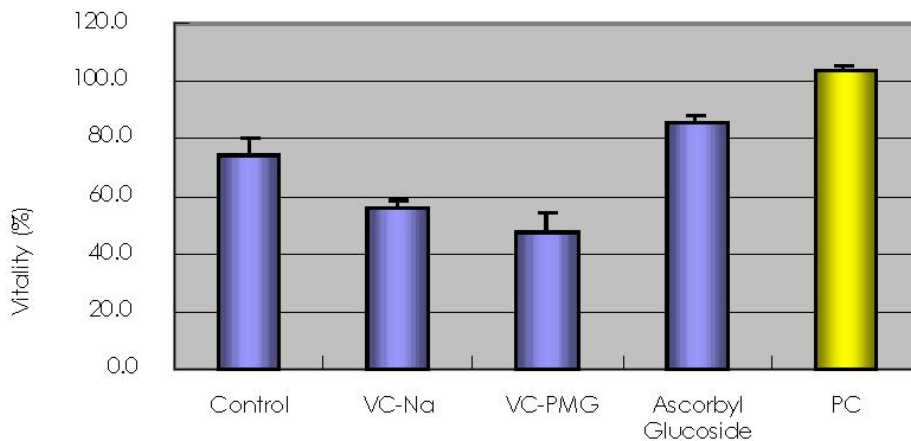
## Anti-oxidant

### Protection of Cell damage induced by H<sub>2</sub>O<sub>2</sub>



HaCaT keratinocytes were treated with various 100 mM of various vitamin C derivatives for 24 h. After treatment of 20 mM H<sub>2</sub>O<sub>2</sub> for 2 h, cell survival was estimated. Significance: \*p<0.05.

### Protection of Cell damage induced by t-BHP (tert-butylhydroperoxide)



HaCaT keratinocytes were treated with various 100 mM of various Vitamin C derivatives for 24 h. After treatment of 1.0 mM of t-BHP for 4 h, cell survival was estimated. Significance: \*\*p<0.01.

### SOD-Like Activity

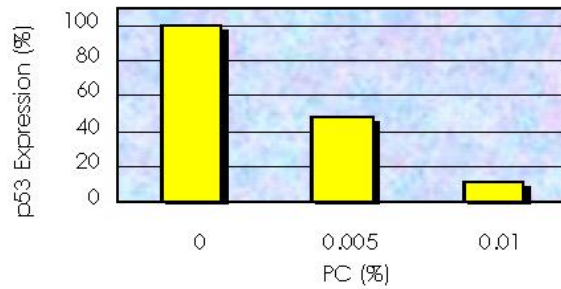
The amount of Diformazan formed by the reduction of Nitro Blue Tetrazolium by superoxide anions (O<sub>2</sub><sup>-</sup>) was determined by measuring the absorbance (NBT reduction method). This was then used as the indicative value for SOD-like activity of PC. Before the measurement, 0.1mL of PC was added to 2mL of the sample. As a result, PC inhibited 40% of Diformazan formation. This confirms the SOD-like activity of PC.

## PC protects skin from UVB

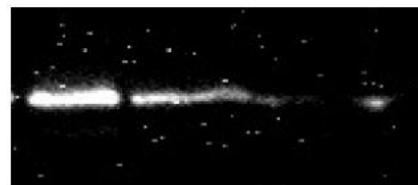


### Protection of DNA from UVB irradiation

When cells are exposed to UVB rays, a cancer suppressor, p53 protein, is activated in response to DNA damage. The amount of expressed p53 was measured as an indicator of the amount of damage to DNA. Human fibroblasts (NB1RGB); UVB (0.1 J/cm<sup>2</sup>). PC significantly inhibited the expression of p53.



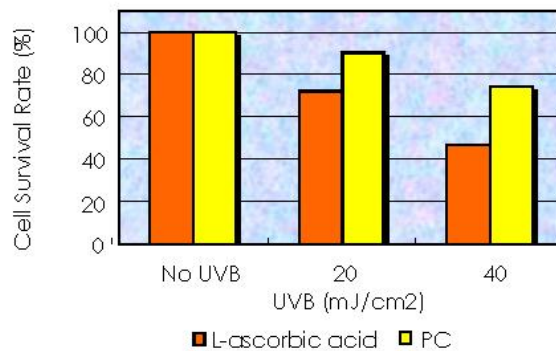
p53 Expression (Western Blot)



0 0.005 0.01 (%)  
PC (%)

### Reduction of cell damage caused by UV Irradiation

PC and L-ascorbic acid were added at the concentration of 10  $\mu$  mol/L to epidermal cells. The cells were then irradiated with UVB. After a 24-hour cultivation, cell survival rate was measured by WST-1 assay. Protective effect of PC was higher than that of L-ascorbic acid due to the fact that the conversion rate of PC into the cells is higher than that of pure ascorbic acid.



## PC protects skin from UVB

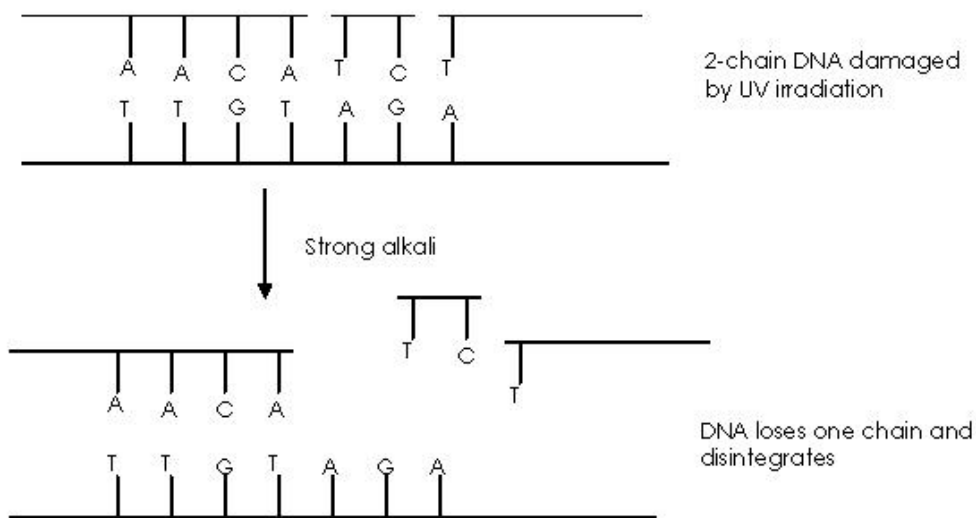


### Comet Assay Test

The comet assay, also called the 'Single Cell Gel Assay', is the technique to detect DNA damage and repair at the level of single cells. The comet assay or single cell gel electrophoresis assay is based on the alkaline lysis of labile DNA at sites of damage. 'Comet Assay' is one of the most popular tests of DNA damage detection (e.g., single- and double-strand breaks, oxidative-induced base damage, and DNA-DNA/DNA-protein cross linking) by electrophoresis, developed in recent years.

Comet Assay has very high sensitivity to detect DNA damage.

### Idea

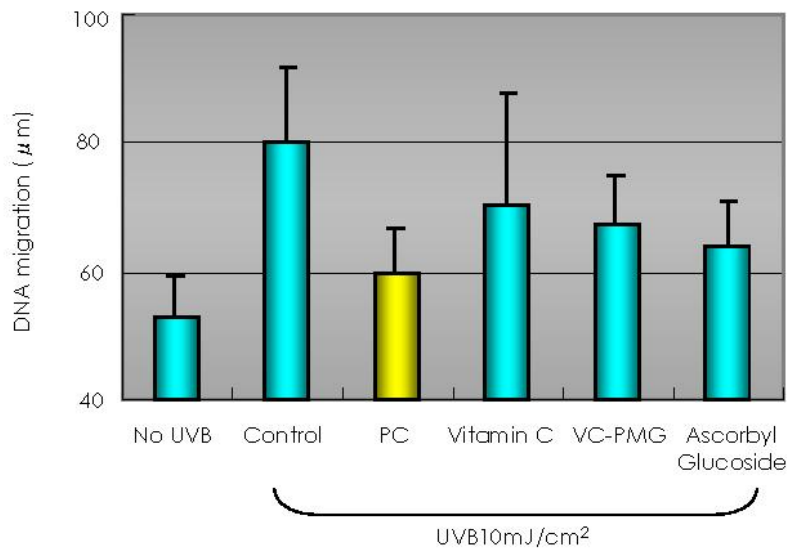




## PC protects skin from UVB



### Suppression of DNA damage induced by UVB (Comet Assay test)



DNA damage was evaluated by the comet assay. HaCaT keratinocytes which were treated with VC derivatives for 24 h, were exposed to UVB at 100 mJ/cm<sup>2</sup>.



DNA damage was evaluated by the comet assay. HaCaT keratinocytes which were treated with PC for 24 h, were exposed to UVB at 100 mJ/cm<sup>2</sup>. Cells are stained with etidium bromide.

## PC protects skin from UVA



### Inhibition of keratinocytes' DNA damage induced by UVA

The light parts on the pictures (taken 1 hour after of UVA irradiation) indicate 8-hydroxyguanosine, an index of DNA damage. The application of PC inhibits the release of 8-hydroxyguanosine, thereby protecting the cell against UVA damage.



No treatment



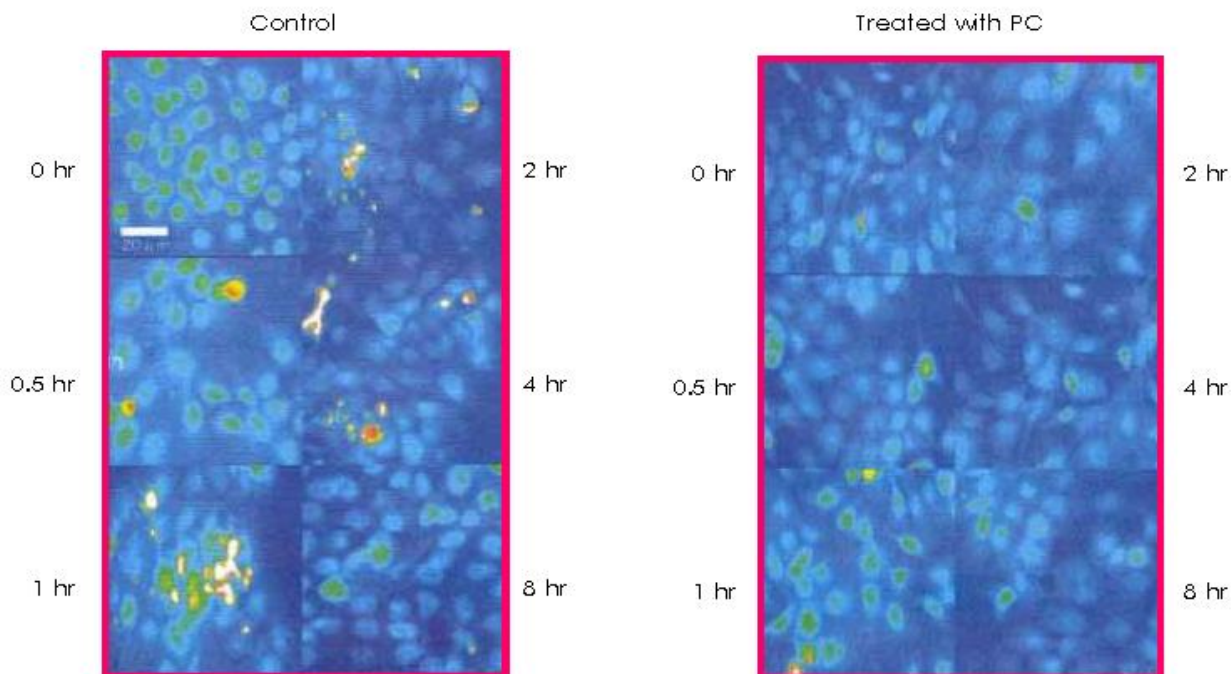
PC (80 mM)

### Protection of cell damage induced by UVA

Microscopic pictures of keratinocytes 24 hours after irradiation. PC treatment reduces cell death by 31.5%.



### Inhibition of DNA Fragmentation induced by UVA



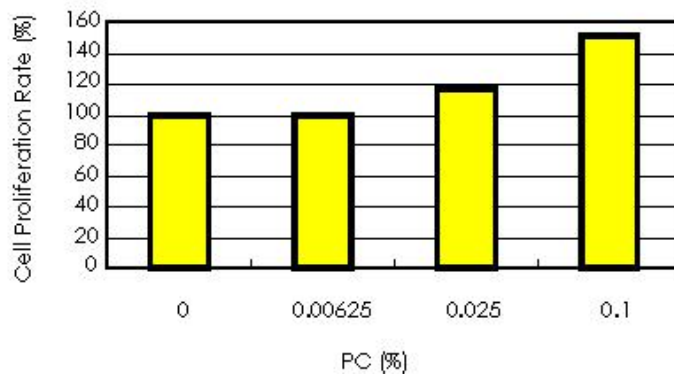
HaCaT cells were treated with 80 mM PC. After UVA irradiation, DNA fragmentation was detected by nick end labeling method (TUNEL). PC significantly suppressed DNA fragmentation (shown with fluorescent staining).

## Anti-aging Properties



### Cell Revitalizing Activity / Cell Proliferation

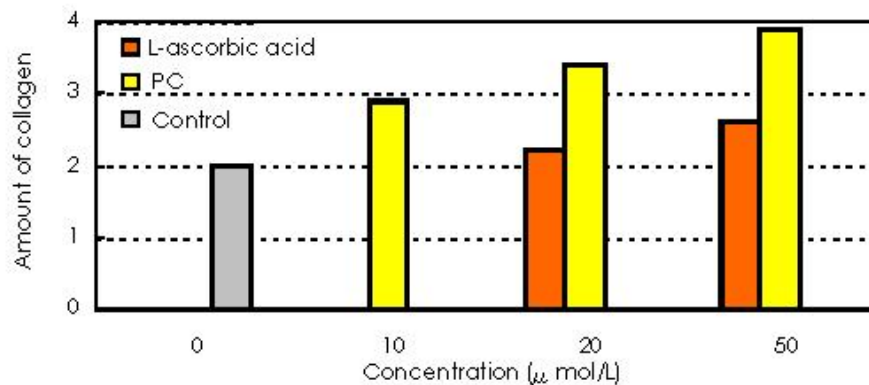
PC was added at various concentrations to human fibroblasts (NB1RGB). After 3 days of cultivation, the cell growth rate was measured by MTT reduction assay. As shown below, PC proliferated human fibroblasts. And the result was dose-dependent.



Cell Revitalizing Activity of PC

### Promotion of Collagen Synthesis

Proline involved in collagen synthesis was labeled by  $^3\text{H}$  and added to human dermal fibroblasts (NHDF) with various concentrations of PC/L-ascorbic acid and cultivated for 24 hours. Then collagen fractions were obtained. The amount of  $^3\text{H}$  taken into the collagen fraction was measured by using a liquid scintillation counter and slot blotter. As shown below, PC significantly promoted collagen synthesis.



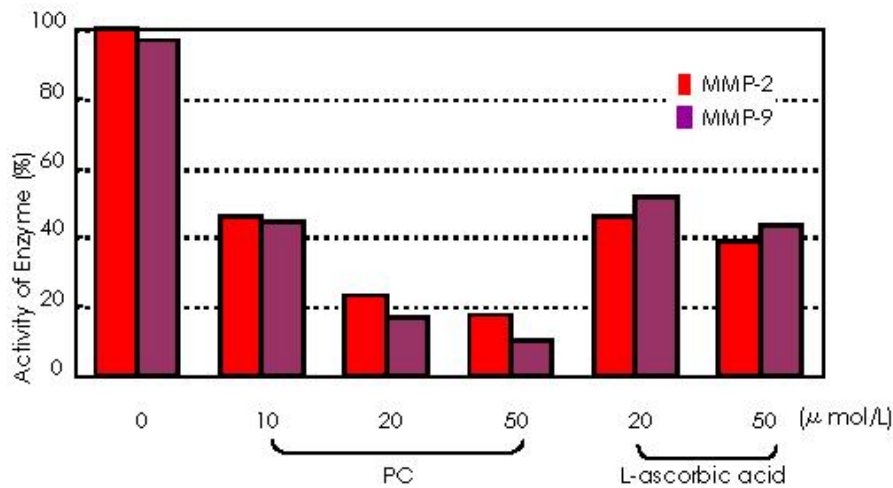
Promotion of Collagen Synthesis

## Anti-aging Properties



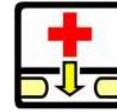
### Inhibition of Activity of Collagen Degrading Enzyme

PC was added at concentrations of 10-50  $\mu\text{mol/L}$  to human dermal fibroblasts (NHDF). After a 48-hour cultivation, secreted material was obtained. The activity of two types of collagen degrading enzymes, MMP-2 (72kDa) and MMP-9 (92kDa), in the secreted material were evaluated by gelatin zymography. PC drastically inhibited the activity of both MMP-2 and MMP-9. The inhibitory effect was considerably higher than that of L-ascorbic acid.



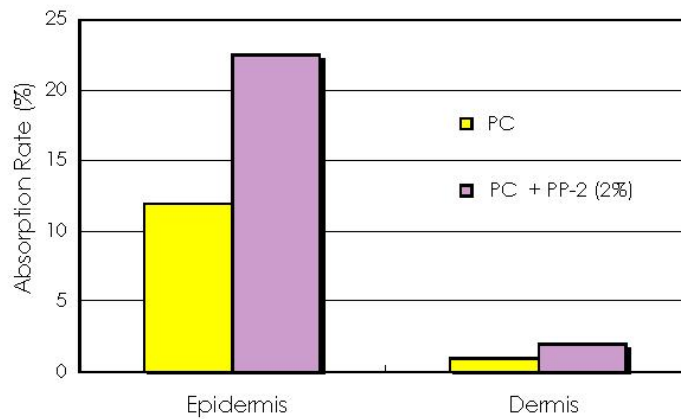
Inhibition of Collagen Degrading Enzyme Activity

## Superior Skin Penetration



### Percutaneous Absorption of PC

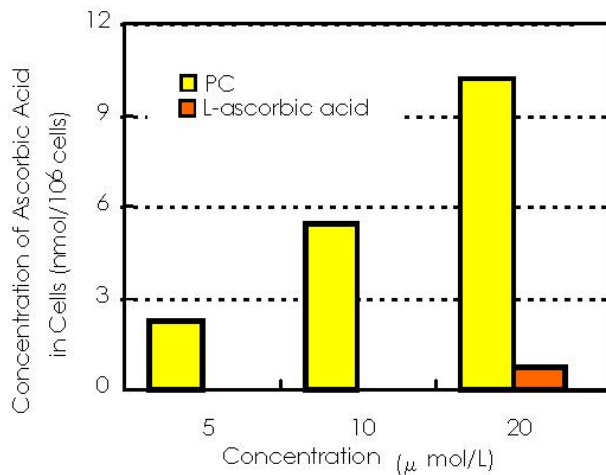
Percutaneous absorption of PC was measured with a tissue section isolated from human skin. PC showed superior penetration ability into the epidermis. PC is an oil-soluble liquid and has a high affinity for the skin. This seems to explain the excellent percutaneous absorption. This ability can be enhanced when PC is used together with Polyolprepolymer-2 (PP-2, Bertek Pharmaceuticals).



Percutaneous Absorption of PC

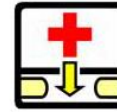
### Efficient Absorption into Human Dermal Fibroblasts

The absorption of PC into human dermal fibroblasts (NHDF) was measured as a concentration of ascorbic acid 2 hours after adding PC. As shown below, the intake of ascorbic acid into the skin after the addition of PC was considerably higher than that after the addition of L-ascorbic acid by itself. It was proven that PC was rapidly broken down into ascorbic acid at a high conversion rate.



Absorption of PC into Human Fibroblasts

## Superior Skin Penetration



### Evaluation of human skin penetration of PC and Ascorbyl Glucoside

Subjects: 8.

Test site: forearm.



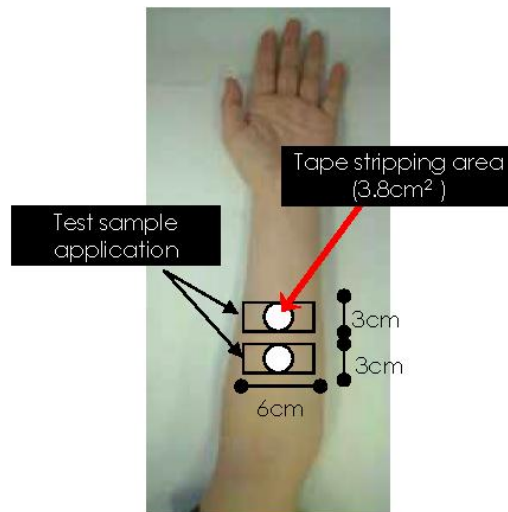
Cream with 10% PC  
Cream with 10% Ascorbyl Glucoside



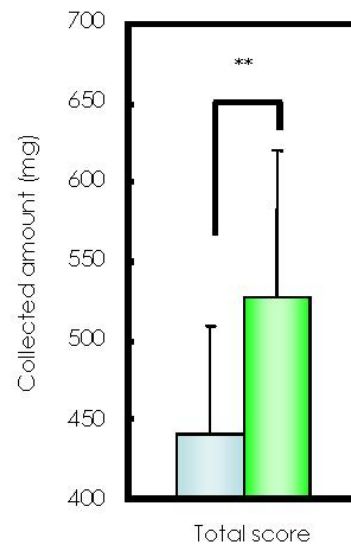
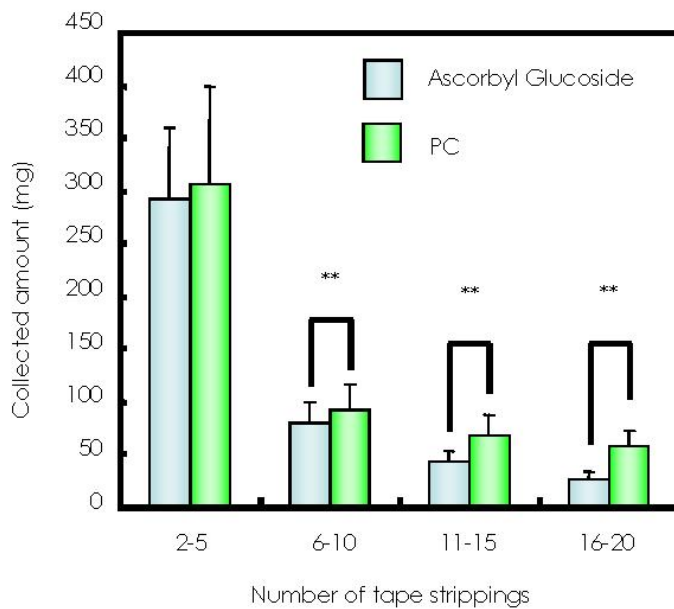
Application time: 1 hour



Tape stripping from test sites is performed 20 times



Amount of PC and Ascorbyl Glucoside collected by tape stripping is evaluated by HPLC



\*\* :  $p < 0.05$

## Solubility of PC

The solubility of PC in various cosmetic raw materials was measured at 25, 50 and 75°C. PC is soluble in most oils, whether polar oil or non-polar, except polyhydric alcohols.

Concentration of PC (wt%)	5			10			50		
Temperature (°C)	25	50	70	25	50	70	25	50	70
Glycerin	I	I	I	I	I	I	I	I	I
Propylene Glycol	I	I	I	I	I	I	I	I	I
1,3-Butylene Glycol	I	I	I	I	I	I	I	I	I
Ethanol	S	S	S	S	S	S	I	S	S
Propyleneglycol Monocaprylate	S	S	S	S	S	S	S	S	S
Castor Oil	S	S	S	S	S	S	S	S	S
Triethylhexanoin	S	S	S	S	S	S	S	S	S
Olive Oil	S	S	S	S	S	S	S	S	S
Cetyl Ethylhexanoin	S	S	S	S	S	S	S	S	S
Mineral Oil	S	S	S	S	S	S	S	S	S

S: Soluble I: Insoluble

## Instructions for Use

PC has superior stability compared with other vitamin C derivatives. However, it may discolor under some specific conditions. Design preparations in the pH range not higher than 6.0. The use of chelating agents and anti-oxidants (tocopherol) in the formulation is recommended because they are effective to prevent discoloration. Since contact with water may induce oxidation of PC, add surfactants with long chain polyoxyethylenes to stabilize the system, strengthening the interfacial membrane. Avoid heating for long periods of time.

## Stability of PC in cream

Stability of PC assay and pH of cream (10% aq. solution) at 45 degrees Celsius x 3 months.

Emulsifier: glyceryl stearate.  
PC: 3.3%. Oil phase: 10%.  
PH adjustment: citric acid / sodium citrate.

