needle-free syringe.

## PRECEDING TECHNICAL DOCUMENTS

Patent Documents:

[0007]

Patent Document 1: JP2003-534839;

Patent Document 2: United States Patent No. 2,704,542;

Patent Document 3: United States Patent Publication No. 2006/0258986;

Patent Document 4: United States Patent Publication No. 2005/0010168.

Non-Patent Documents:

[0008]

Non-Patent Document 1: Joy Baxter, Samir Mitragotri, "Jet-induced skin puncture and its impact on needle-free jet injections: Experimental studies and a predictive model", Journal of Controlled Release (U.S.A.) 106 (2005), p361-373;

Non-Patent Document 2: Joy Schramm-Baxter, Samir Mitragotri, "Needle-free jet injections: dependence of jet penetration and dispersion in the skin on jet power", Journal of Controlled Release (U.S.A.) 97 (2004), p527-535.

## SUMMARY

Problem to Be Solved:

[0008a] In one aspect of the present disclosure, there is provided a method of constructing a syringe for injecting an injection objective substance into an injection target of a living body without using any injection needle, the method including:

providing, within the syringe, an enclosing unit which encloses the injection objective substance;

providing, within the syringe, an ignition unit which includes an ignition charge capable of generating a plasma having a high temperature and a high pressure during combustion immediately after the ignition, and suddenly lowering the high pressure generated such that no gas component is contained when an ordinary temperature is provided and a combustion product is condensed;

providing, within the syringe, a combustion chamber into which the condensed combustion product is allowed to flow and which accommodates a gas generating agent that is to be combusted by the combustion product to produce a predetermined gas;

providing, within the syringe, a pressurizing unit which pressurizes the injection objective substance enclosed in the enclosing unit; and

providing, within the syringe, a flow passage unit which defined a flow passage so that the injection objective substance, which is pressurized by the pressurizing unit, is allowed to inject to the injection target area,

wherein the pressurizing unit is capable of providing,

a first pressurizing mode in which a pressure applied to the injection objective substance in the pressurizing unit is raised to a first peak pressure in order to allow the injection objective substance to penetrate through a surface of the injection target area,

and then the pressure applied to the injection objective substance is lowered to a waiting pressure; and

a second pressuring mode in which the injection objective substance having the waiting pressure is pressurized so that the pressure applied to the injection objective substance is raised to a second peak pressure to inject a predetermined injection amount of the injection objective substance,

characterized in that

the pressurizing unit uses,

an increase in pressure generated by the combustion of the ignition charge in the ignition unit as a pressurization transition until arrival at the first peak pressure in the first pressurizing mode, and

an increase in pressure brought about by the predetermined gas produced by the gas generating agent as a pressurization transition until arrival at the second peak pressure in the second pressurizing mode.

**[0009]** When the injection is performed for the living body, the component which is contained in the injection solution and the depth in the injection target area of the living body into which the component is to be fed differ depending on the purpose of the injection. This is because the injection target area of the living body includes various structures such as skin, muscle, internal organs and the like, and the biological tissues, which constitute the structures, have different functions depending on the depths from the surface (surface on which the syringe is brought in contact with the structure when the injection is performed), and because it becomes difficult to

appropriately exhibit the effect if the component contained in the injection solution does not arrive at the objective biological tissue.

[0010] For example, the human skin can be distinguished or classified into epidermis, dermis, and subcutaneous tissue (hypodermis) in a layered form from the surface side. Further, the epidermis can be distinguished or classified into horny cell layer and intradermis. In order that the respective layers perform the respective functions anatomically, the horny cell layer is composed of keratinocytes, the intradermis is composed of dendritic cells and pigment cells, the dermis is composed of fibroblasts and collagen cells, and the subcutaneous tissue is composed of subcutaneous fat and the like. When an injection solution is injected for a predetermined purpose,

it is preferable that the predetermined component contained therein is precisely delivered, for example, to the objective tissue.

[0011] In order that the injection objective substance is efficiently injected without a leakage when the injection objective substance is injected into the injection target area of the living body, it is necessary that the pressure, which is applied to the injection objective substance, should be appropriately controlled from the start to the end of the injection. That is, if the injection speed (velocity) of the injection objective substance, which is brought about by the pressurization, is too slow, the substance is rebounded by the skin. To the contrary, if the injection speed (velocity) is too fast, then the injection depth can be secured in the injection target area, but the injection speed exceeds an injection speed which is adequate to diffuse the substance in the area. Therefore, it is considered that the injection objective substance is rebounded due to the excessive supply, and it is difficult to contemplate the appropriate diffusion thereof. Taking the foregoing problem into consideration, an object of the present disclosure is to provide a syringe which makes it possible to feed an injection objective substance into an objective injection target area of a living body without using any injection needle so that the injection objective substance can be widely diffused at a depth.