

DISCHARGE DEVICE FOR CENTRIFUGING A REACTION VESSEL UNIT, CENTRIFUGE, AND METHOD FOR CLEANING A DISCHARGE DEVICE

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Field of the Invention

The present invention relates to a discharge and collecting device for a reaction vessel unit, a centrifuge, and a method for cleaning a discharge device.

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Reaction vessel units which have several reaction vessels, such as microtiter plates (MTP, well plates or multi-well plates) with a plurality of wells, can be cleaned by centrifugation. The MTPs are attached to a rotor in a rotor chamber of a centrifuge in such a way that the openings of the reaction vessels face away from the axis of rotation of the rotor and are centrifuged at a speed of up to several thousand revolutions per minute.

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In this context, cleaning means that the liquid contained in the reaction vessels is evacuated. The reaction vessels are cleaned by filling and evacuating liquids. However, reagents can also be added, which must then be evacuated from the reaction vessels after a reaction has taken place (e.g. chemical, biological, or biophysical). The solid phase in a reaction vessel unit can be the inner wall of the reaction vessels, cells adhering to them, cells or cellular structures located therein, particles held therein, or even magnetic particles located therein. The following aspects of contamination apply to all formats.

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During centrifugation, the contents ejected from the reaction vessels are collected by a wall of the rotor chamber. Substances remaining on the walls and surfaces of the rotor chamber partly flow off and collect in the lower region of the rotor chamber, but can also drip down from above and, for example, end up in an MTP located in the rotor chamber. If several microtiter plates are cleaned one after the other in the centrifuge, there is also a risk of cross-contamination due to centrifugate from one MTP dripping into another MTP.

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The rotation of the rotor creates air vortices in every centrifuge. If liquid contents are ejected from the reaction vessels during rotation, these air vortices cause aerosols to form. These can float in the air and travel anywhere. They are a significant cause of cross-contamination. In ge-

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conomic applications (typically amplification-based such as PCR), aerosols are therefore the driving force for contamination.

It has also been shown that microtiter plates cleaned in the centrifuge can still be wet on the surface even after the wells have been completely emptied. This can make further use more difficult, for example if the microtiter plates are subsequently sealed with a film. The foil is typically adhesive-mounted to cover the openings of the wells. This can be done, for example, for sterile intermediate storage of the microtiter plates before further use or after filling with a test liquid to isolate the test regime. The wetted surface, however, makes it difficult to adhesive-mount a foil onto the microtiter plates.

Prior Art

A centrifuge is known from publication DE 10 2017 113 583 A1 in which the housing below the rotor has a discharge channel and the inner surfaces of the housing adjacent to the channel form a funnel that opens into the channel. This allows the centrifugate that accumulates in the rotor chamber to be collected and discharged more easily.

It is known from publication DE 10 2021 124 023 A1 to supply a cleaning solution to the rotor chamber of a centrifuge in such a way that the cleaning solution is distributed in the rotor chamber by rotation of the rotor. Residues of the centrifugate can thus be removed from the walls and surfaces of the rotor chamber by regular, frequent rinsing with cleaning agents.

The German patent applications DE 10 2022 102 701.5 and DE 10 2022 102 705.8, which have not yet been published, describe discharge devices for the controlled discharge of liquids from reaction vessels by means of a centrifuge.

For reasons of hygiene, comparatively frequent cleaning cycles are required, which leads to idle times and high operating costs. This procedure cannot be avoided, however, particularly for diagnostic applications.

Problem

The problem of the invention is to provide devices and a method that improve the cleaning of a reaction vessel unit by centrifugation in a centrifuge, in particular that minimize the contamination

tion of the interior of the centrifuge and optimize the discharge of liquids exiting the reaction vessels.

Solution

5 This problem is solved by the subjects of the independent claims. Advantageous further embodiments of the subjects of the independent claims are characterized in the dependent claims. The wording of all of the claims is hereby incorporated into the content of this description by reference.

10 The use of the singular shall not exclude the plural, which shall also apply in the reverse sense, unless otherwise disclosed.

To solve the problem, a discharge device for centrifuging a reaction vessel unit is proposed. The reaction vessel unit has a plurality of reaction vessels, the reaction vessels each having an opening that lies in a common opening plane. Typically, the reaction vessel unit is a microtiter plate. The discharge device has a discharge plate, which is embodied in such a way that in a centrifuge having a rotor with an axis of rotation, it can be or is positioned opposite from the openings of the reaction vessels, and in such a way that it rotates with the reaction vessel unit during centrifugation and liquid exiting the reaction vessels due to the centrifugal acceleration is collected and discharged by the discharge plate. On the side of the discharge plate facing the openings of the reaction vessels, there is at least one fin, which is positioned approximately parallel to the axis of rotation of the rotor and transverse to the direction of movement of the discharge plate.

25 Due to its inertia, the fin prevents the entirety of the liquid ejected from the reaction vessels from flowing to the outer edge of the discharge plate counter to the direction of rotation. The liquid droplets hitting the discharge plate in the direction of rotation in front of the fin flow along the discharge plate and counter to the direction of rotation until they are stopped by the fin and from there, they are discharged along the fin in a controlled manner.

30 The expression "direction of movement of the discharge plate" is understood here as the direction tangential to the radius at which the discharge plate is spaced from the axis of rotation. The direction of rotation during centrifugation thus describes a circular path concentric to the axis of rotation.

The discharge device with the discharge plate keeps liquid ejected from the reaction vessels during centrifugation away from the other elements of the device, such as the housing of the centrifuge, the rotor, and in particular, the axis of rotation of the rotor. The at least one fin ensures that ejected liquid is discharged in an optimal way. This achieves a whole range of advantages: corrosion and/or other chemical interactions with the ejected liquid are prevented since essentially only the inside of the discharge device comes into contact with the liquid.

Since the volume containing the liquid rotates together with the rotor, no air turbulence is produced. This greatly reduces the risk of aerosols forming.

Cross-contamination of reaction vessel units during centrifugation is largely prevented, as is wetting of the reaction vessel unit. In addition, the cleaning effort is considerably reduced because the rotor chamber of the centrifuge has to be cleaned much less frequently since the ejected liquid is collected by the discharge device. This means that only this discharge device needs to be cleaned or replaced. A suitable cleaning method for this is described below.

The discharge of liquid ejected during centrifugation is further optimized if, in the discharge device described above, a discharge surface of the discharge plate pointing toward the reaction vessel unit is inclined relative to the axis of rotation of the rotor in such a way that the distance between the discharge surface and the axis of rotation of the rotor increases in the direction toward the discharge opening of the centrifuge. This generates a component of the centrifugal force directed toward the discharge opening during centrifugation, which drives the liquid toward the discharge opening during centrifugation. At high rotation speeds, at which the liquid is pressed against the discharge plate with several Gs, the liquid is removed from the discharge plate without residue or almost without residue. This can minimize the need to clean the discharge device.

Preferably, the at least one fin is positioned with its length oriented at an angle to the axis of rotation of the rotor in such a way that liquid exiting the reaction vessels upon acceleration of the rotor is guided by the fin in the direction toward the discharge opening. The position of the fin extends approximately parallel to the axis of rotation and is increasingly offset backward relative to the discharge opening in relation to the direction of movement of the discharge device. The fins thus extend approximately like a screw thread around the axis of rotation.

Due to the inertia of the liquid, it is driven along the fin in the direction toward the discharge opening upon acceleration of the rotor and thus upon acceleration of the discharge device. Experiments have shown that most of the liquid is ejected from the reaction vessels during the acceleration process and is driven out of the discharge device.

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The angle that the fins form with the axis of rotation is preferably at least 3° , in particular at least 5° , and can also be at least 10° .

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The angle that the fins form with the axis of rotation is preferably not greater than 45° and in particular not greater than 30° or not greater than 20° .

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The discharge of liquid ejected during centrifugation can be further improved if, in the discharge device described above, the inclination of the fin relative to the axis of rotation of the rotor is greater in a region adjacent to the discharge opening than in a region farther away from the discharge opening. As a result, the liquid flows to the discharge opening more easily and without backing up.

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The aforementioned embodiment of the at least one fin in the discharge device described can preferably be achieved by the fin being curved or having one or more bends along its length.

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In a preferred modification of the discharge device already described, several fins are provided. In particular, these are positioned approximately parallel to one another. This can further improve the discharge of the liquid ejected from the reaction vessels, especially if several discharge openings are present. At least three or at least four or even at least five fins can be provided.

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Preferably, the discharge plate is curved in such a way that it forms a segment of a body that is approximately rotationally symmetrical to the axis of rotation. In particular, the discharge plate can therefore be approximately the shape of the surface of a conical segment. This allows the internal volume of the discharge device, in which liquid can occur, to be kept particularly small.

The discharge device can be embodied with several fins. In this way, the liquid ejected from the reaction vessels is divided into several liquid volumes, each of which is discharged along one of the fins.

The several fins are preferably positioned approximately parallel to one another, wherein the distance between adjacent fins can widen with increasing distance from the axis of rotation.

To discharge liquid along the fins, it is sufficient for either the discharge plate to be at an increasing distance from the axis of rotation in the direction toward the discharge opening (inclined position of the surface of the discharge plate facing the rotor) or for the fin(s) to be positioned at an angle to the axis of rotation. Preferably, both inclined positions are provided in the discharge device. This allows the liquid to be discharged with two effects.

All of the embodiments result in minimizing the residence time of the ejected liquid in the collecting chamber above the reaction vessels, thus dramatically reducing the risk of contamination by aerosols.

In an advantageous modification of the described discharge device for centrifuging a reaction vessel unit, the discharge plate can be attached to the rotor of the centrifuge or to the reaction vessel unit by means of a detachable coupling mechanism, with the coupling mechanism being embodied in particular as a quick-release fastener, especially preferably as a linearly couplable quick-release fastener. An embodiment of the quick-release fastener as a bayonet fastener is particularly preferred. The discharge device can thus be attached to the rotor of the centrifuge or to the reaction vessel unit in a particularly easy and time-saving way. Attaching the discharge device to the reaction vessel unit instead of to the rotor can further reduce the risk of contamination of the centrifuge rotor.

The problem is further solved by a centrifuge with a rotor, which is mounted so that it is able to rotate around an axis of rotation, and with a discharge device, as already described, with which a liquid can be guided to a discharge opening of the centrifuge. The discharge device is detachably connected to the rotor or to a reaction vessel unit installed in the rotor in such a way that it rotates together with the rotor. A discharge chute leads away from the discharge opening. A rinsing device is provided to rinse the discharge chute with a cleaning liquid. This ensures that all potentially contaminated parts of the centrifuge can be effectively cleaned without a great deal of additional effort.

Individual method steps are described in more detail below. In a preferred variant of the invention, the steps are carried out in the order indicated. The steps do not necessarily have to be car-

ried out in the order indicated, however, and the method to be described can also comprise further steps not mentioned.

To solve the problem, a method for cleaning a discharge device in a centrifuge is also proposed.

5 The discharge device has a discharge plate which is embodied in such a way that it is positioned opposite from the openings of the reaction vessels of a reaction vessel unit in the centrifuge and in such a way that it rotates with the reaction vessel unit during centrifugation and liquid exiting the reaction vessels due to the centrifugal acceleration is collected and discharged by the discharge plate. The method comprises the following steps:

10 1. inserting a reaction vessel unit into the rotor of the centrifuge, wherein at least one reaction vessel of the reaction vessel unit is filled with a cleaning liquid.

15 2. rotating the rotor to a position in which the discharge plate is positioned below the rotor so that the cleaning liquid flows out of the at least one reaction vessel and is collected by the discharge plate.

3. acting of the cleaning liquid to on the discharge plate for a predetermined period of time

20 4. removing the cleaning liquid from the discharge plate by spinning the rotor.

In this way, the discharge device can be cleaned in a reproducible manner with little effort.

25 The present discharge device is a modification of the discharge devices described in the German patent applications DE 10 2022 102 701.5 and DE 10 2022 102 705.8. Reference is therefore made to these documents in their entirety.

30 Further details and features ensue from the following description of preferred embodiments in conjunction with the figures. The respective features can be implemented individually or several at a time in combination with one another. The possibilities for solving the problem are not limited to the exemplary embodiments. The exemplary embodiments are shown schematically in the figures. Identical reference numerals in the individual figures denote identical or functionally identical elements or elements that correspond to each other in terms of their functions. All graphic representations are to be understood as schematic. Size ratios may be distorted for clari-

ty. Unless otherwise indicated, directional and positional descriptions refer to the normal use of the subject of the invention. In detail:

Fig. 1 shows the interior of a rotor box of a centrifuge with a reaction vessel unit and a discharge device in a cross-sectional view from the front;

Fig. 2 shows a three-dimensional oblique view of a discharge device seen from the side facing the reaction vessel unit;

Fig. 3 shows a three-dimensional oblique view of the discharge device from Fig. 2 seen from the side facing away from the reaction vessel unit;

Fig. 4 shows a plan view of the side of the discharge device facing the reaction vessel unit;

Fig. 5 shows a plan view of the reaction vessel unit seen from the side of the discharge device facing away from the reaction vessel unit; and

Fig. 6a to 6c show cross-sectional views through the discharge device from Fig. 5 cutting along the lines A-A, B-B, and C-C.

A centrifuge 1 has a drive box (not shown in detail) and a rotor box 3, which rest on feet 4 (Fig. 1). The drive box typically houses a drive unit such as an electric motor. The drive box has a cover 5, which is attached to a support structure of the rotor box 3 by means of screws. The support structure can be formed by an end wall, a base 27, and a rear wall 28 of the rotor box 3. The cover 5 can have two side walls 13 and an upper wall 14, which are embodied as individual elements or, for example, as a continuous bent sheet metal structure (see Fig. 1). The side walls 13 and the upper wall 14 of the cover 5 as well as the end wall, a base 27, and a rear wall 28 of the rotor box 3 define or surround an interior of the rotor box 3, which is also referred to as a rotor chamber 29. The end wall typically has a loading window through which an interior of the rotor box 3 is accessible in order to load the centrifuge with a reaction vessel unit 21 (Fig. 1) in an intrinsically known way. The end wall can also have an axle opening that accommodates a rotor shaft of the centrifuge 1 for rotation around an axis of rotation. The axle opening can also be embodied as a bearing seat for a bearing for supporting the rotor shaft, but the rotor shaft can also travel freely in the axle opening.

The rotor shaft supports a rotor 20, which is connected to the rotor shaft in a rotationally coupled manner in order to rotate in an interior of the rotor box 3 (Fig. 1). For this purpose, the rotor shaft is connected to an output shaft of the drive unit of the centrifuge 1. Alternatively, it is also conceivable for the rotor shaft to be an integral part of the output shaft of the drive unit. The rotor 20 is embodied to accommodate at least one reaction vessel unit 21. In the present exemplary embodiment, the rotor 20 can accommodate two reaction vessel units 21, but only one of these is shown in Fig. 1.

The rotor 20 has a frame 22, which is embodied as roughly cuboid and is or can be connected to the rotor shaft in a rotationally coupled manner. On each of two radially opposite sides of the frame, a receptacle 23 is embodied for a reaction vessel unit 21. In embodiment variants, it is also possible for only a single receptacle 23 or more than two receptacles 23 to be provided. The receptacle 23 is preferably delimited by two rail-like clamps 24 that protrude from the frame 22. A support surface 25 for the reaction vessel unit 21 is embodied on the frame 22 itself, while respective counterpart surfaces 26 are embodied on the clamps 24, which are parallel to the support surface 25 and are spaced apart from it to fit a height of the reaction vessel unit 21.

Instead of a reaction vessel unit, a weight plate can also be provided in a receiving area, which forms a corresponding counterweight to the reaction vessel unit.

The reaction vessel unit 21 can be placed on or removed from the rotor 20 in an intrinsically known manner via the loading window in the end wall when the rotor 20 is in a position in which the receptacle is exactly opposite the loading window. The loading process can be carried out automatically, for example by means of a loading device of the kind that is known from WO 2017/125598 A1. For this purpose, the loading device has an automatically operable displacement rod (not shown) for positioning a reaction vessel unit.

The reaction vessel unit 21 is a body with a plurality of individual reaction vessels 37, which are arranged next to one another in the reaction vessel unit 21 and each have an opening 38 on one side (Fig. 1). The openings 38 lie in a common opening plane 39 and point radially outward for cleaning purposes. The clamps 24 of the receptacles 23 are embodied such that they grip the reaction vessel unit 21 only at the edge so that the openings 38 of the individual reaction vessels 37 of the reaction vessel unit 21 remain exposed. When the rotor 20 rotates around the axis of rota-

tion at a suitable rotation speed, liquids contained in the reaction vessels 37 of the reaction vessel unit 21 are ejected radially outward. The rotation speed for this is a few hundred to a few thousand rpm.

5 According to an exemplary embodiment of the present invention, a discharge device 30 is provided, which is positioned radially outside the reaction vessel unit 21 (Fig. 1). The discharge device 30 has a discharge plate 31, which is positioned opposite from the openings 38 of the reaction vessels 37. The discharge plate 31 extends beyond the dimensions of the rotor 20 both in the width direction w and in the axial direction (direction of the axis of rotation). In modifica-
10 tions, it can be sufficient if the discharge plate 31 covers at least the reaction vessel unit 21 or at least all of the openings 38 of the reaction vessels 37 of the reaction vessel unit 21. When the rotor 20 rotates at a speed suitable for centrifugation, liquid from the reaction vessels 37 is propelled through the openings 38 by the effect of the centrifugal force and collected by the discharge plate 31.

15 In the case of a roughly planar discharge plate, a radial distance r_0 of the discharge plate 31 from the axis of rotation is at its smallest in the region of a central plane 36, which extends at right angles through the opening plane 39 of the reaction vessel unit 21 and along the axis of rotation (Fig. 1), while the radial distance r increases in the width direction w toward the edge 32 of the
20 discharge device. Accordingly, a centrifugal acceleration also increases toward the edge 32 of the discharge device 30 so that the collected liquid is driven along a surface of the discharge plate 31 in the width direction w toward the edge 32.

Preferably, however, the discharge plate 31 is concavely curved with its discharge surface facing
25 the rotor or the reaction vessel unit so that it forms a kind of channel that extends approximately parallel to the axis of rotation. In particular, the discharge surface is embodied so that it is approximately concentric to the axis of rotation. As a result, there are no effects or only minor effects due to centrifugal forces that vary in the direction of rotation. However, due to its inertia, the liquid is driven along the discharge surface in the direction opposite the direction of move-
30 ment.

The discharge device 30 also has at least one fin 40, preferably several of them, on the discharge surface facing the openings 38 of the reaction vessels 37, with the fin being positioned approximately parallel to the axis of rotation of the rotor and transverse to the direction of movement of

the discharge plate (not shown in Fig. 1 for the sake of simplicity). In the present exemplary embodiment, the surfaces of the fins 40 are positioned perpendicular to a plane that extends between the edges of the discharge device 30 with which the discharge device rests laterally on the reaction vessel unit or is attached to the rotor. The surfaces of the fins 40, however, can also be oriented differently, for example radially to the center point of the curved discharge surface or radially to the axis of rotation of the rotor. Through such an arrangement, in which the fins are positioned transversely to the direction of movement of the discharge plate, in a rotating discharge device 30, drops of liquid are entrained by the fins and discharged due to the centrifugal force, with the drops of liquid being discharged along the fins 40 and the discharge surface.

The discharge device 30 can be embodied as integral to the rotor 20 or as attached to it or attachable to it. In particular, the discharge device 30 can be removable from the rotor 20 so that it can be cleaned separately. The discharge device 30 can also be attached to the rotor shaft or to the reaction vessel unit 21 independently of the rotor 20 (not shown in detail).

A more detailed depiction of a preferred embodiment of the discharge device 30 can be seen in Figs. 2 to 6c.

As explained above, the discharge device 30 is embodied to execute a rotary movement together with a rotor in a centrifuge. This discharge device 30 thus has elements with which the discharge device 30 can be attached directly or indirectly to the rotor. An indirect attachment to the rotor is achieved, for example, by attaching the discharge device to the reaction vessel unit 21. The attachment must of course be sufficiently stable to ensure that the discharge device 30 is securely attached to the rotor despite the considerable centrifugal forces (e.g. up to about 500 G) that occur during centrifugation. Such a discharge device 30 therefore always has a certain shape and/or fastening means that allow such a stable and unambiguous attachment to the rotor. As a result, when the discharge device 30 is used for its intended purpose, it is always placed in a specific and unambiguous position relative to the rotor and its axis of rotation. In the following description, elements of the discharge device 30 are explained in relation to the axis of rotation of the rotor as well as in relation to the direction of movement of the rotor or discharge device. In this explanation, without explicit reference being made to it each time, the discharge device 30 is attached to the rotor in an unambiguous position when in use. A person skilled in the art can recognize from the embodiment of the discharge device, even if the discharge device were to be

detached from the rotor, how the corresponding elements are positioned in relation to the axis of rotation of the rotor.

In this embodiment of the discharge device 30, the discharge plate 31 is embodied as the inner surface (= discharge surface) of the discharge device 30 and is curved in such a way that it forms a segment of a body that is approximately rotationally symmetrical to the axis of rotation (see oblique depictions in Fig. 2 and Fig. 3). The resulting shape is essentially a conical segment. On the inner discharge surface of the discharge device 30, there are fins 40 (four in the embodiment depicted) which, when the discharge device is mounted, are positioned approximately parallel to the axis of rotation of the rotor and transverse to the direction of movement of the discharge plate.

Fig. 2 and Fig. 4, however, clearly show that the fins 40 are not positioned exactly parallel to the axis of rotation of the rotor, but rather at a slight angle to it. This contributes significantly to a better discharge of the collected liquid upon acceleration of the rotor and the collecting device. Fig. 2 and Fig. 4 also show that the inclination of the fins 40 relative to the axis of rotation of the rotor is greater in a region adjacent to the discharge opening, i.e. in the foreground in Fig. 2 and at the bottom in Fig. 4, than in a region farther away from the discharge opening. This is achieved by means of a bend 43 in the embodiment shown.

The discharge device 30 has a discharge channel 45, which connects to the discharge plate 31 on the side where the fins 40 for discharging the liquid end. On this side, the collection chamber 50, which is delimited by the discharge plate 31 in the radial direction, is delimited by an end wall 46, against which the corresponding ends of the fins 40 rest. This end wall 46 has the discharge opening 44, which in the present exemplary embodiment is formed for manufacturing reasons from two separate discharge openings 44 (Fig. 6A), each of which is arc-shaped. Instead of the two discharge openings 44, one or more discharge openings can also be provided. The discharge openings 44 are aligned with their radially outer edge with the discharge surface of the discharge plate 31 adjacent to the end wall 46. As a result, liquid that is driven along the fins 40 can pass through the discharge openings 44 unhindered.

A hollow body 47 is placed on the end wall 46 on the side facing away from the discharge plate 31 or the side facing away from the fins 40, which defines an arc-shaped discharge channel 45. The discharge channel 45 extends radially outside the discharge plate 31 and has an output open-

ing 48 on the radially outer edge facing the discharge plate 31. In operation, the output opening 48 opens into a discharge chute formed on the centrifuge housing, which collects the liquid that is driven out of the collection chamber 50 along the fins 40 through the discharge channel 45 and discharges it downward into a collection vessel.

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In the present exemplary embodiment, both the discharge surface of the discharge plate 1 is embodied such that it is inclined relative to the axis of rotation of the rotor during operation, with the maximum distance between the discharge surface and the axis of rotation being adjacent to the discharge channel 45, and the fins 40 are arranged at an angle relative to the axis of rotation in the plan view (for example Fig. 4), so that the liquid, which is ejected from the reaction vessels, is acted upon both by the inclined position of the discharge surface due to the centrifugal forces and by the inclined position of the fins due to the inertia of the liquid, which forces drive the liquid toward the discharge channel 45. In principle, it is sufficient if either the discharge surface is inclined or the fins are inclined with respect to the axis of rotation. If both the discharge surface of the discharge plate 31 and the fins 40 are arranged at an angle, two effects act on the liquid to drive it out of the collection chamber. This achieves a maximum expulsion effect on the liquid.

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The discharge device 30 can be embodied with a collecting pocket 49 at the rear region in the direction of rotation 41, with which liquid is collected that is not caught by one of the fins 40 and is guided from there to the discharge openings 44 in the discharge channel 45.

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Preferably, the edges of the discharge device 30 are embodied such that both the front and rear edges in the direction of movement 41 of the discharge device 30 are flush with the corresponding reaction vessel unit 21 or the rotor 20. As a result, the collecting chamber 50, which is formed in the region between the rotor and the discharge device 30, is closed in the direction of movement 41, so that no air flow takes place through the collecting chamber 50 due to the rotation of the rotor and the discharge device.

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The air atmosphere in the collection chamber 50 thus rotates together with the rotor and the discharge device 30. As a result, there is no turbulence that causes aerosols. Preferably, the collection chamber is also hermetically sealed at both ends by corresponding end walls in order to prevent or minimize an exchange of the atmosphere with the rest of the rotor chamber.

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The sectional plane of Fig. 6c intersects a fin 40 in the region of the bend 43.

The discharge device 30 can be detachably connected to the rotor 20 of the centrifuge 1 or to the reaction vessel unit 21, for which purpose a coupling mechanism 42 is provided. In the embodiment shown, the coupling mechanism 42 is realized in that a perforated band is integrally formed on the front and rear edges of the discharge device 30 in the direction of movement (see Figs. 2-4). By means of plug-in elements, screws or the like, the discharge device can thus be detachably connected to the respective counterpart on the rotor 20 or on the reaction vessel unit 21 (not shown). However, a design of the coupling mechanism as a linearly couplable quick-release fastener or as a bayonet fastener is preferred due to the better manageability.

The coupling mechanism 42 can also be embodied in such a way that it forms an outwardly protruding flap at the front and rear edge of the discharge device 30 in the direction of rotation, which is dimensioned in such a way that, together with the reaction vessel unit 21, it fits into the receptacle 23 of the rotor 20 in a positively engaging way. When using the rotor that is shown by way of example in Fig. 1, these flaps are embodied so that, together with the reaction vessel unit 21, they fit into the receptacle 23 in the region between the bearing surface 25 and the counterpart surfaces 26 so that both the discharge device 30 and the reaction vessel unit 21 are embraced radially on the outside by the counterpart surface 26 and fix the position of the reaction vessel unit 21 and the discharge device 30 in the radial direction.

The discharge device can also be an integral part of the rotor.

The discharge device is preferably made of plastic. It can be intended for single use or for multiple use.

Preferably, the discharge device, in particular its discharge surface and the fins, is coated with a layer, in particular a hydrophobic layer, which promotes the discharge of liquids.

The discharge chute of the centrifuge, into which the output opening 48 of the discharge channel 45 of the discharge device 30 feeds during operation, is embodied approximately in the form of a concentric ring around the axis of rotation and in particular around the area that the rotor and discharge device sweep through during one revolution, and has an outlet in the lower region in order to guide the liquid into a receiving container.

The discharge chute can be provided with a rinsing device so that the discharge chute can be rinsed with cleaning fluid. This rinsing device has one or more nozzles for dispensing the cleaning liquid. The nozzles can be provided with an atomizer so that the cleaning fluid is distributed in the discharge chute. This cleaning method is preferably carried out when the centrifuge is not in operation, i.e. when no reaction vessel unit is being cleaned with the centrifuge.

This discharge device or a centrifuge having such a discharge device can be used to clean reaction vessels or to clean bodies or substances contained in the reaction vessels, for example beads, by removing liquid that is contained in the reaction vessels. The reaction vessels are cleaned by filling them with liquids and then removing the liquids by centrifuging. In the same way, however, reagents can also be added, which must then be removed from the reaction vessels after a reaction has taken place (e.g. chemical, biological, or biophysical). The solid phase in a reaction vessel unit can be the inner wall of the reaction vessels, cells adhering to it, cells or cellular structures located therein, particles contained therein, or even magnetic particles located therein.

As explained above, this discharge device 30 has elements with which the discharge device 30 can be attached directly or indirectly to the rotor. The attachment must, of course, be stable enough to ensure that the discharge device 30 remains securely attached to the rotor despite the considerable centrifugal forces (e.g. up to about 500 G) that occur during centrifugation. The discharge device preferably has fastening means in order to fasten it directly and in particular detachably to the rotor. In this case, the discharge device can be embodied in such a way that it delimits a receptacle for receiving a specific reaction vessel unit. Such an embodiment has the advantage that different types of reaction vessel units can be centrifuged with the same centrifuge or the same rotor by replacing the discharge device, which is embodied to accommodate a different type of reaction vessel unit. This increases the flexibility of the centrifuge.

Reference Symbols

			25		
			33	flank	
			36	center plane	
5	1	centrifuge	37	reaction vessel	
	3	rotor box	38	opening	
	4	foot	30	39	opening plane
	5	cover	40	fin	
	13	side wall	41		
	14	upper wall	42	coupling mechanism	
10	20	rotor	43	bend	
	21	reaction vessel unit	35	44	discharge opening
	22	frame	45	discharge channel	
	23	receptacle	46	end wall	
	24	clamp	47	hollow body	
15	25	support surface	48	output opening	
	26	counterpart surface	40	49	collecting pocket
	27	base	50	collecting chamber	
	28	rear wall	r	radius	
	29	rotor chamber	r ₀	smallest radius	
20	30	discharge device	w	width direction	
	31	discharge plate			
	32	edge			

Cited Patent Literature

- DE 10 2017 113 583 A1
- 5 DE 10 2021 124 023 A1
- WO 2017/125598 A1
- DE 10 2022 102 701.5 (subsequently published)
- DE 10 2022 102 705.8 (subsequently published)

CLAIMS

1. A discharge device (30) for centrifuging a reaction vessel unit (21), which has a plurality
5 of reaction vessels (37);

1.1 wherein the reaction vessels (37) each have an opening (38) that lies in a common opening
plane (39);

1.2 wherein the discharge device (30) has a discharge plate (31), which is embodied in such a
10 way

1.2.1 that in a centrifuge (1) having a rotor (20) with an axis of rotation, it can be or is positioned
opposite from the openings of the reaction vessels (37); and

1.2.2 that it rotates with the reaction vessel unit (21) during centrifugation and liquid exiting the
15 reaction vessels (37) is collected and discharged by the discharge plate (31);

1.3 wherein the discharge plate (31) is curved in such a way that it forms a segment of a body
20 that is approximately rotationally symmetrical to the axis of rotation of the rotor (20) and an inner
surface of the discharge plate (31) forms a discharge surface, which during centrifugation,
faces the openings of the reaction vessels (37), wherein the discharge surface is provided with at
least one fin (40), which is positioned approximately parallel to the axis of rotation of the rotor
(20) and transverse to the direction of movement of the discharge plate (31)

1.4 wherein the discharge surface of the discharge plate (31) facing the reaction vessel unit (21)
25 is inclined relative to the axis of rotation of the rotor (20) in such a way that the distance of the
discharge surface from the axis of rotation of the rotor (21) increases in the direction toward a
discharge opening (44); and/or

1.5 the at least one fin (40) is arranged with its length oriented at an angle to the axis of rotation
30 of the rotor (20) in such a way that liquid exiting the reaction vessels (37) upon acceleration of
the rotor (20) is guided by the fin (40) in the direction toward the discharge opening (44).

2. The discharge device (30) according to claim 1, characterized in that the inclination of the fin (40) relative to the axis of rotation of the rotor (20) is greater in a region adjacent to the discharge opening (44) than in a region farther away from the discharge opening (44).

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3. The discharge device (30) according to claim 2, characterized in that the fin (40) is curved or has one or more bends along its length.

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4. The discharge device (30) according to one of claims 1 to 3, characterized in that

5.1 several fins (40) are provided;

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5.2 wherein the fins (40) are in particular positioned approximately parallel to each other.

5. The discharge device (30) according to one of claims 1 to 4, characterized in that the discharge plate (31) is curved in such a way that it forms a segment of a body that is approximately rotationally symmetrical to the axis of rotation.

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6. The discharge device (30) according to one of claims 1 to 5, characterized in that the discharge plate (31) can be attached to the rotor (20) of the centrifuge (1) or to the reaction vessel unit (21) by means of a detachable coupling mechanism (42).

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7. The discharge device (30) according to claim 6, characterized in that the coupling mechanism (42) is embodied as a quick-release fastener, in particular as a linearly couplable quick-release fastener.

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8. A centrifuge (1) with a rotor (20) which is mounted so that it is able to rotate around an axis of rotation; and

8.1 with a discharge device (30) according to one of claims 1 to 7, with which it is possible to guide a liquid to a discharge opening (44) of the centrifuge (1) or discharge device (30);

5 8.1.1 wherein the discharge device (30) is detachably connected to the rotor (20) or to a reaction vessel unit (21) inserted in the rotor (20) in such a way that it rotates together with the rotor (20);

8.2 wherein a discharge chute (41) leads away from the discharge opening (44);

10 8.3 wherein a rinsing device for rinsing the discharge chute (41) with a cleaning liquid is provided.

9. A method for cleaning a discharge device (30) in a centrifuge (1), wherein the discharge
15 device (30) has a discharge plate (31), which is embodied in such a way that it is positioned opposite from the openings (38) of the reaction vessels (37) of a reaction vessel unit (21) in the centrifuge (1), and in such a way that it rotates with the reaction vessel unit (21) during centrifugation and liquid exiting the reaction vessels (37) due to the centrifugal acceleration is collected and discharged by the discharge plate (31), with the following steps

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9.1 introducing a reaction vessel unit (21) into the rotor (20) of the centrifuge (1), wherein at least one reaction vessel (37) of the reaction vessel unit (21) is filled with a cleaning liquid,

25 9.2 rotating the rotor (20) so that the cleaning liquid flows out of the at least one reaction vessel (37) and is collected by the discharge plate (31),

9.3 acting of the cleaning liquid on the discharge plate (31) for a predetermined period of time,

30 9.4 removing the cleaning liquid from the discharge plate (31) by rotating the rotor (20), characterized in that a discharge device according to one of claims 1 to 7.